2008
FLUE-CURED TOBACCO
production guide

Virginia Tech and Virginia State – Virginia's Land Grant Universities in cooperation with the Virginia Bright Flue-cured Tobacco Board

Virginia Cooperative Extension

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2008
FLUE-CURED TOBACCO
production guide

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FLUE-CURED TOBACCO BUDGET INFORMATION

Eric Eberly, Extension Agent, Farm Business Management

Introduction

The flue-cured tobacco budget is an estimate of the costs to produce 2,500 pounds of marketable tobacco. Expenses values used in the budget are based upon projected input prices and recommended production practices. Producers are encouraged to adjust this budget using the right-hand column to reflect production practices and prices that are relevant to their own farming operations. This column is your estimated costs.

Budget Assumptions

1. The projected average flue-cured tobacco price is estimated to be $1.68 per pound. The price includes contract incentives.

2. Diesel fuel costs for tractor and equipment operation is projected at $2.85 per gallon. The equivalent gallons of diesel fuel are increased by 15 percent to cover oil and lubrication cost of equipment.

3. LP Gas for curing is projected to be $1.95 per gallon.

4. Labor cost is estimated to be $11.44 per hour. It includes the projected adverse wage for Virginia of 8.98 and indirect labor costs of $2.46 per hour. The indirect labor cost per hour is calculated by dividing total indirect labor costs of $12,270 (association fees, transportation, housing, insurance, etc.) by 5,000 hours of labor (50 acres x 100 hours).

5. Crop insurance premium is based on 75 percent of actual production history at a price of $1.60 per pound.

Budget Interpretation

Income and expense items for the 2008 budget are broken down into four separate sections: Gross Receipts, Preharvest Variable Costs, Harvest Variable Costs, and Fixed Costs. Explanations of the items that fall into each section and the economic returns that can be calculated are detailed below.

- Gross Receipts represents per-acre cash income to the tobacco operation and is calculated by multiplying the average yield per acre by the average gross contract price per pound.

- Preharvest costs are typically cash expenses that must be paid annually to produce a crop of tobacco prior to harvest. Examples of preharvest variable costs include plants, fertilizer, chemicals, machinery fuel and repairs, and hired labor.

- Harvest costs are cash expenses getting the tobacco from the field to the buying station. Examples of harvest costs include harvest labor, curing fuel, and electricity.

- Total Variable Costs is the sum of preharvest and harvest variable costs. Variable costs are often called “cash costs” or “out-of-pocket expenses.”

- Return over variable costs is simply the gross receipts of the crop minus the total variable costs. This value essentially can be viewed as the return over “cash costs” or the return over “out-of-pocket expenses.”

- Fixed Costs are the expenses that result from the ownership of equipment and buildings. Examples of fixed costs include depreciation, property taxes, interest, and insurance on the barns and machinery.

- Other fixed cost includes a return to overhead. Overhead cost is calculated by multiplying the expenses invested (total variable costs) in the crop by 8 percent.

- The return to land, risk, and management is calculated by subtracting the total variable costs and the fixed expenses from Gross Receipts. This represents the return to the operator’s land (the equivalent of an annual land charge or rental value), time (unpaid operator/family labor), and management skills employed in producing a crop.

Flue-cured tobacco – contact, irrigated

Estimated Costs and Reurns Per Acre: 2500 Pound Yield

						Acres 1
		Unit	Quantity / Acre	Price or Cost/Unit	Total/Acre	Your Farm
1. Gross Receipts						
FLUE-CURED TOBACCO		LBS	2500.00	$1.68	$4,200.00	
Total Receipts:					**$4,200.00**	
2. Preharvest Variable Costs						
TOBACCO PLANTS - Flue-cured		1M	6.20	$30.00	$186.00	____________
Cover Crop: Rye		BU.	2.00	$10.35	$20.70	____________
Lime (Prorated)		TON	0.56	$32.50	$18.28	____________
FRow: Fertilizer (6-12-18)		CWT	6.50	$20.13	$130.85	____________
Sidedress: (13-0-14)		CWT	2.50	$20.30	$50.75	____________
Herbicides		ACRE	1.00	$5.36	$5.36	____________
Insecticides		ACRE	1.00	$69.14	$69.14	____________
Fungicides		ACRE	1.00	$91.91	$91.91	____________
Nematicides		ACRE	1.00	$185.90	$185.90	____________
Sucker Control		ACRE	1.00	$79.20	$79.20	____________
Federal Crop & Hail Insurance		ACRE	1.00	$73.94	$73.94	____________
Land Rent		ACRE	1.00	$0.00	$0.00	____________
Tractor Equipment: Fuel & Oil		Eq Gal	48.00	$2.85	$136.79	____________
Tractor & Equipment: Repairs		ACRE	1.00	$63.17	$63.17	____________
Tractor & Equipment: Labor		HRS	24.68	$12.00	$296.16	____________
Hand Production Labor		HRS	40.00	$11.44	$457.60	____________
Production Interest	5	Months	$777.40	7.5%	$58.30	____________
Total Preharvest Costs			**$0.77 Per Pound**		**$1,924.05**	____________
3. Harvest Variable Costs						
Tractor Equipment: Fuel & Oil		Eq Gal	14.67	$2.85	$41.82	____________
Tractor & Equipment: Repairs		ACRE	1.00	$17.87	$17.87	____________
Tractor & Equipment: Labor		HRS	9.98	$12.00	$119.76	____________
Hand Harvest Labor		HRS	60.00	$11.44	$686.40	____________
Curing Fuel (LP)	12	gal/cwt	300.00	$1.95	$585.00	____________
Building Ins. & Electricity		ACRE	1.00	$107.68	$107.68	____________
Supplies		ACRE	1.00	$10.60	$10.60	____________
Total Harvest Costs:			**$0.63 Per Pound**		**$1,569.13**	____________
4. Total Variable Costs			**$1.40 Per Pound**		**$3,493.18**	____________
5. Return Over Total Variable Cost					**$706.82**	____________
6. Machinery Fixed Costs (Based on new equipment cost)		Acre	1.00	$678.29	$678.29	____________
7. Other Fixed Costs		Dol	$3,493.18	**8.0%**	**$279.45**	____________
8. Total Fixed Costs					$957.74	
9. Total Variable & Fixed Costs			**$1.78 Per Pound**		**$4,450.92**	
10. Projected Net Returns To Land, Risk and Management:					**-250.92**	

* Please note: this budget is for planning purposes only.

* Fertilizer requirements will vary with application method, and/or residual nutrient levels in the soil.

Since yield and average sale price will vary from farm to farm each year, calculated returns over variable costs with varying yield and price levels are displayed in the following table.

Income above variable costs at differing yields and prices

Farm Yield	Total Variable Costs			Farm Price ($/lb)		
Lb.	**Cost/Acre**	**1.58**	**1.63**	**1.68**	**1.73**	**1.78**
2000	3,376.18	(216.18)	(116.18)	(16.18)	83.82	183.82
2250	3,434.68	120.32	232.82	345.32	457.82	570.32
2500	3,493.18	456.82	581.82	706.82	831.82	956.82
2750	3,551.68	793.32	930.82	1,068.32	1,205.82	1,343.32
3000	3,610.18	1,129.82	1,279.82	1,429.82	1,579.82	1,729.82

This budget was developed in Microsoft Excel and is available from your local Extension office or online at: *www.vaes.org.vt.edu/SPAREC/Ftobacco.xls*

AGRONOMIC INFORMATION

T. David Reed, Extension Agronomist, Tobacco

Variety Selection

Variety selection is an important decision for the profitable production of flue-cured tobacco. A high potential yield is probably more important than ever due to lower tobacco prices and reduced operating margins. However, ease of curing and specific characteristics of the cured leaf should also be considered. Varieties will differ in cured-leaf color and other physical characteristics desired by purchasers (proportion of tip leaves, etc.), but these factors are also influenced by growing and curing practices. Growers should carefully consider any dramatic changes in varieties grown without first trying the varieties first-hand. Likewise, the disease resistance of varieties varies greatly and is critical to profitable production. Growers should maintain detailed field histories with specific information on past varieties planted and the level of disease occurrence.

Tobacco breeders have made tremendous progress in recent years developing resistance to the major diseases of flue-cured tobacco. Detailed information on the disease resistance of flue-cured tobacco varieties is presented in the disease section of this guide. It is especially important that growers have a correct identification of any diseases that may be causing field losses. Black shank, Granville wilt, and *Pythium* stalk rot may be confused and the presence of nematodes can make these and other root diseases more severe than expected or symptoms may not appear as expected. To further complicate matters, there have been isolated cases of the less common root diseases that are not typically tested against our current varieties. If past performance of disease resistant varieties has been less than anticipated, growers are encouraged to contact their local agriculture Extension agent to investigate possible explanations and evaluate options.

No official figures are compiled for tobacco seed sales or varieties planted in Virginia. Growers have dozens of varieties available with a wide range in disease resistance properties, yield potential, leaf characteristics, and ease of handling and curing. Perhaps as much as 75 percent of the flue-cured acreage in Virginia in 2007 was planted in three varieties (K 326, NC 71, and NC 297). The long popular K 326 remains the most planted variety in Virginia due to its high yield, exceptional holding ability, and ease of curing. The variety was released in 1981 and still remains a good choice for growers with good rotations and field histories with no disease or nematode problems. Black shank is perhaps the most widespread disease problem in Virginia and growers have readily adopted varieties such as NC 71, and to a lesser extent, NC 291 and NC 72, to reduce losses due to this disease. Many of these same varieties possess resistance (Ph gene) to the tobacco cyst nematode and have provided dramatic reductions of nematode population levels. Granville wilt is a more localized disease that is primarily a problem in Mecklenburg and Brunswick Counties, and therefore, additional varieties are of interest in this area. K 149, and later, Speight 168, have historically been the variety grown for Granville wilt resistance. In recent years, newer varieties with greater resistance levels and yield potential are being grown, including NC 299, GL 350, and NC 810. Recent new releases from Speight Seed Farms show quite a lot of promise for Granville wilt. Finally, some growers desire resistance to the tobacco mosaic virus (TMV) and NC 297, CC 27, and RG H4 are TMV resistant varieties that have significantly better quality than earlier TMV resistant varieties.

Only one new variety will be released commercially for the 2008 season, following approval by the Regional Flue-cured Tobacco Minimum Standards Program the previous year.

CC 37 was developed by the tobacco breeding program at R.J. Reynolds Tobacco Company. The variety was developed with an emphasis on incorporating resistance to species of the root rot nematode other than the common root knot nematode to which most other commercial varieties are resistant. Only a very few growers in Virginia need to consider this resistance when making a choice on varieties to grow. The seed CC 37 is a hybrid so the parental cross is not public knowledge. Disease resistance can be considered similar to the previously released CC 27 with high race 0 black shank resistances and TMV resistance. In the limited testing conducted to date, CC 37 is considered to have a high level of resistance to Granville Wilt.

The results from the Official Variety Trial conducted at the Southern Piedmont Center in 2007 are shown in **Table 1. Relative yield** is calculated based on the overall average yield of all varieties in the test. A value of 100 indicates that the yield was the same as the test average. Values of 105 or 95 indicate that the yield of a particular variety was 5 percent above or below the test average, respectively. **Average price** was calculated based on a set of composite prices from multiple contract buyers. These prices tended to be lower than what you would expect when marketing the tobacco due to the difference in the appearance of the tobacco in small hands from the test compared to an 800 pound bales. The grade index is a better measure of the quality difference among varieties. When examing these data, one should remember that the data are from one year only. For more detailed information on varieties, refer to *Flue-cured Tobacco Variety Information for 2008*, Virginia Cooperative Extension publication 436-047 (Revised 2008). Additional information regarding disease resistance may be found in the disease control section of this guide.

Table 1. Agronomic results from the 2007 Official Variety Trial conducted at Southern Piedmont AREC - Blackstone.

New varieties for 2008 are bold.

Variety	Yield (lbs/A)	Relative Yield	Price ($/lb)	Grade Index	Value ($/A)
CC 27	3890	114	1.37	79.0	5372
PVH 1118	3768	110	1.34	77.0	5022
CC 37	**3756**	**110**	**1.30**	**73.3**	**4714**
NC 196	3726	109	1.38	77.3	5134
NC 102	3704	109	1.37	78.0	5076
NC 299	3695	108	1.41	80.7	5228
NC 72	3620	106	1.30	74.3	4694
RGH 51	3581	105	1.36	77.7	4851
NC 291	3580	105	1.35	77.0	4832
GL 350	3560	104	1.35	77.3	4814
NC 71	3558	104	1.30	74.7	4613
K 394	3492	102	1.13	66.0	3938
OX 414	3472	102	1.44	81.3	4991
Speight G-168	3460	101	1.31	75.7	4535
RG H4	3437	101	1.41	80.3	4868
K 326	3431	101	1.38	79.0	4724
Speight 234	3428	100	1.12	66.0	3842
Speight 227	3413	100	1.44	82.0	4917
Speight 220	3409	100	1.37	78.0	4663
NC 810	3389	99	1.32	76.0	4479
VA 119	3380	99	1.25	72.7	4220
RG 17	3377	99	1.32	75.3	4430
Speight H20	3372	99	1.36	77.7	4584
GL 939	3368	99	1.32	75.0	4430
CC 13	3352	98	1.34	76.7	4532
K 730	3335	98	1.42	80.3	4740
NC 55	3334	98	1.46	82.3	4872
VA 116	3328	98	1.38	79.3	4599
NC 297	3293	97	1.24	70.7	4088
K 399	3259	96	1.36	77.0	4434
NC 606	3247	95	1.37	77.7	4446
K 358	3236	95	1.27	72.7	4128
Speight 225	3235	95	1.39	79.0	4493
Speight 236	3202	94	1.39	79.7	4451
Coker 371Gold	3195	94	1.34	76.3	4276
Speight 210	3182	93	1.38	78.0	4387
K 346	3170	93	1.36	77.3	4326
Speight NF3	3141	92	1.40	79.3	4401
NC 471	3100	91	1.35	78.0	4183
K 149	3008	88	1.28	74.7	3878
Test Average	3412		1.34	76.8	4580

The test was grown at the Southern Piedmont Agricultural Research and Extension Center in Blackstone with no black shank or Granville wilt incidence. The tobacco cyst nematode was controlled with Temik 15G (20 lbs/A).

Table 2. Relative yields for Flue-cured Tobacco Official Variety Trials conducted at the Southern Piedmont AREC near Blackstone for 2006 and 2007.

Variety	2007 Relative Yield		2006 Relative Yield		2-yr Average Relative Yield
CC 27	114	(1)	113	(2)	113
PVH 1118	110	(2)	99	(25)	105
CC 37	**110**	**(2)**			
NC 196	109	(4)	110	(4)	110
NC 102	109	(4)	105	(9)	107
NC 299	108	(6)	106	(8)	107
NC 72	106	(7)	113	(2)	109
RG H51	105	(8)	103	(15)	104
NC 291	105	(8)	109	(7)	107
GL 350	104	(10)	101	(20)	103
NC 71	104	(10)	103	(15)	104
K 394	102	(12)	89	(38)	95
OX 414	102	(12)	105	(9)	104
Speight G-168	101	(14)	101	(20)	101
RG H4	101	(14)	100	(24)	101
K 326	101	(14)	110	(4)	105
Speight 234	100	(17)	103	(15)	102
Speight 227	100	(17)	99	(25)	99
Speight 220	100	(17)	98	(28)	99
NC 810	99	(20)	105	(9)	102
VA 119	99	(20)	101	(20)	100
RG 17	99	(20)	101	(20)	100
Speight H20	99	(20)	91	(37)	95
GL 939	99	(20)	95	(31)	97
CC 13	98	(25)	116	(1)	107
K 730	98	(25)	99	(25)	99
NC 55	98	(25)	105	(9)	102
VA 116	98	(25)	87	(40)	92
NC 297	97	(29)	110	(4)	103
K 399	96	(30)	95	(31)	95
NC 606	95	(31)	95	(31)	95
K 358	95	(31)	96	(30)	95
Speight 225	95	(31)	94	(35)	94
Speight 236	94	(34)	68	(41)	81
Coker 371 Gold	94	(34)	92	(36)	93
Speight 210	93	(36)	98	(28)	96
K 346	93	(36)	105	(9)	99
Speight NF3	92	(38)	95	(31)	94
NC 471	91	(39)	89	(38)	90
K 149	88	(40)	102	(18)	95

Relative yield data from the Flue-cured Official Variety Trial for the past two seasons are presented in Table 2. The small number in parenthesis indicates the ranking of a specific variety among all of the varieties for each season. The test conducted at the Southern Piedmont AREC should be indicative of the yield potential of the different varieties grown under a well-irrigated disease-free situation.

Greenhouse Transplant Production

Greenhouse culture has become the standard for transplant production with flue-cured tobacco producers in Virginia. Virtually all of Virginia's flue-cured tobacco acreage has been planted with greenhouse-grown transplants the past several years. The popularity of using greenhouse-grown transplants has created a new business opportunity for many growers, the custom growing of tobacco transplants. Today, a significant number of growers no longer grow their own transplants but purchase them from a transplant producer. When purchasing transplants, the best practice is to buy plants from a reputable grower in or near your local community. This is an important consideration if greenhouse pesticide applications are desired or if specific disease varieties are in your disease management program. If this is not an option, ask other growers about the reputations of prospective transplant producers outside your local area. Importing transplants from southern tobacco belts increases the likelihood of importing blue mold into Virginia and should be avoided.

The use of greenhouse-grown transplants has been advantageous for numerous reasons. Labor required for transplant production and for transplanting has been dramatically reduced compared to the use of bare-root transplants. Crop growth in the field tends to be much more uniform, resulting in easier cultivation and fewer trips through the field when topping. The results have been tobacco crops that grow-off and come into top more uniformly, and this will often carry over into the maturation and ripening of the leaves. Greenhouse management does require more time and different practices compared to traditional outdoor plant beds. Greenhouse sanitation and proper management are critical in avoiding disease problems as pesticide options are limited in the event of serious disease outbreaks. With the increased cost of LPG, growers selling transplants should carefully consider the actual cost of producing transplants. In addition to adding to the cost of heating the greenhouse, increased fuel prices will increase the cost of other items related to the greenhouse such as media, fertilizer, and trays.

Seed priming is an important tool of the seed industry to improve the seed performance of many vegetable and flower crops. The seed priming process is a laboratory procedure that begins the initial phase of the seed germination but suspends the process before actual emergence occurs. Seeds are then treated to allow for storage until germination is desired. The result of priming is seeds that typically will germinate at lower temperatures and will germinate quicker and more uniformly under less than ideal conditions. Seed priming often can be used to overcome seed dormancy that can occur naturally. This can be especially important with tobacco seed that is harvested in the fall immediately preceding use in the next greenhouse season. In order to obtain acceptable germination with recently harvested seed of tobacco hybrids or other varieties with poor germination characteristics, seed companies may find it necessary to prime the seed. However, seed purchasers need not make this decision since seed companies have the necessary laboratory test information to determine if seed priming is warranted. The primary disadvantage of seed priming is the reduced shelf life, and therefore, primed seed should not be held over from one season to the next.

Spiral roots continue to be a common occurrence in many tobacco greenhouses. A spiral-root seedling occurs when the growing point of the emerging root tip is damaged and the seedling fails to develop properly. The result is a root that does not penetrate into the surface of the growing medium. Often a secondary root will develop and grow normally allowing the seedling to become established and otherwise grow normally. The survival of spiral-root seedlings depends on their severity and specific growing conditions. Research studying the fate of spiral-root seedlings indicates that approximately one-third will develop to a usable transplant, one-third will result in swell, less than desired seedlings, and one-third will die to fertilizer salts injury.

The specific cause of spiral-root seedlings is not fully understood. Early research indicated that inadequate media aeration (too little air, too much moisture) played an important role in spiral-root seedling occurrence. This has largely been corrected by growers through better attention to tray filling and not overpacking media in the trays. Differences can occur among different brands of media. However, these differences are seldom consistent among greenhouses and are most likely how media tray-filling boxes handle different mixes. Once a grower gets accustomed to a particular mix, tray filling can be adjusted to minimize spiral roots.

Seed coating properties have a significant impact of seed performance and spiral-root seedling occurrence. The seed coating or pellet must wet uniformly and either melt away or split apart properly. Less vigorous seed will have a greater likelihood of having spiral-root seedlings and this is especially true when the pellet separates from the seed is less than desired. This situation is further complicated by the different wetting properties of the various brands of media and their impact on the breaking apart of the seed pellet.

Reducing Spiral-root Incidence. Growers can not alter the inherent properties of the seed and have little impact on media properties. Growers can give special attention to media handling and tray filling. Trays should be filled evenly, avoid overfilling or overpacking media in trays, and dibbled once with a dibbler that concentrates the force in the center of the cell. Research has demonstrated reduced spiral-root incidence with a pyramid dibbler compared to a spherical shape, though the difference is not great. Growers need to be mindful of the condition of their media at purchase and avoid media that is either excessively wet or dry. Media should be stored so to avoid excessively high temperatures and drying. Water should not be added to bags of mix unless expressly directed by the manufacturer.

Greenhouse Management Practices

The following is a brief description of the important management practices required for successful greenhouse production.

1. **Sanitation**

   Sanitation is the primary means of pest control available to greenhouse tobacco producers. Four important areas for sanitation include: the area in and around the greenhouse, people entering the greenhouse, float trays, and clipping equipment and the clipping operation. Specific information on sanitation is presented in the Disease Control chapter of this guide.

2. **Ventilation and Air Circulation**

   Ventilation is necessary to reduce to amount of moisture that naturally accumulates inside the greenhouse and to prevent the occurrence of enormously high temperatures. Brief openings of the side curtains early in the morning and late afternoon are particularity effective in removing moisture-laden air before condensation occurs. Air circulation within the greenhouse is beneficial to reduce temperature stratification, reduce condensation on the underside of the greenhouse cover, remove moisture from the plant canopy, and evenly distribute greenhouse gases. The use of horizontal airflow (HAF) or a polytube system is highly recommended to provide adequate air circulation.

3. **Temperature Control**

   The most demanding period for heating is during the seed germination period. Until maximum germination is obtained, the minimum temperature should be maintained at 70º to 72ºF. Extended periods of cooler temperatures will delay germination and may decrease the uniformity in the size of the seedlings. After germination, the minimum temperature may be initially reduced to 60º to 65ºF and later to 55ºF. Preventing high temperatures is perhaps of even greater importance. Young seedlings are particularly sensitive and the temperature should not be allowed to reach 95ºF during the two- to four-leaf stage. As seedlings grow, they are better able to withstand increasingly higher temperatures, although to reduce stress on the seedlings, the temperature should not be allowed to exceed 100ºF. High temperatures place greater stress on the tobacco seedlings due to increased water evaporation of and the resulting concentration of fertilizer salts on the surface of the growing medium.

   Recent research conducted by David Smith at NCSU has investigated how flue-cured tobacco varieties differ in their germination response to temperature. This research focused on NC 71, which has been characterized as being inconsistent in germination when examined across a large number of greenhouses. Results demonstrated that NC 71 is especially sensitive to temperature conditions. Although a fluctuation in day to night temperatures was beneficial, just moderately excessive daytime temperatures can induce seed dormancy, resulting in delayed germination. The best germination was obtained for NC 71 with a temperature regime of 68º and 85ºF. Although other varieties did better or were not adversely affected by high temperatures, 95º to 105ºF, better overall management of the greenhouse is obtained by preventing such high temperatures whenever possible.

   Avoid seeding too early to reduce the cost of greenhouse heating. High-quality transplants can be grown in seven weeks in most situations, though some growers have found eight weeks may be necessary with 338-cell trays. An added benefit of not seeding too early is that some pest problems may be avoided by minimizing the time that plants are in the greenhouse. Many growers seed their greenhouse when labor or seeding equipment is available. If this occurs during a period of very cold weather, one may decide to provide only minimal heat (prevent freezing) for a few days until better weather conditions occur and less heating will be necessary. Research conducted for three years in Virginia has provided excellent results with providing a nighttime temperature of just 40ºF and keeping the greenhouse cool (open) during the day for a period of three to five days. This allows for seed pellets to soften without beginning seed germination. Afterwards, normal heating can be started. This has been especially beneficial in reducing spiral-root seedlings.

Greenhouse temperatures should be measured at plant level in one or more locations that are representative of the entire greenhouse. The use of a recording thermometer to measure daily high and low temperatures is an excellent management practice. Thermostat settings for heating and cooling should be made of the basis of thermometers within the immediate environment of the plants.

4. Media and Tray Filling

Media and tray filling may be the source of the greatest number of problems for Virginia greenhouse tobacco producers in recent years. Dry cells and spiral roots are each related to media and the tray-filling operation. Assuring that all cells within a tray are uniformly filled and that all trays are similar will improve the uniformity in seed germination and seedling growth. Cells must be completed filled for their entire depth to wick properly and prevent dry cells; but overpacking the cells must be avoided to prevent the occurrence of spiral-root plants. Proper moisture content of the mix is critical for adequate tray filling and the use of a premoistened medium is highly recommended. Better plant stands generally are obtained with a mix having a dry consistency rather than a mix with increased moisture and thus a heavier consistency. The mix needs only enough moisture to keep it from falling through the trays before floating. If the trays wick properly, watering over the top should not be necessary to assist with seed germination. However, if the trays are watered, only a fine mist should be used to prevent packing and waterlogging the medium.

5. Fertilization

Fertilizers used in float greenhouse transplant production are formulated to function with a soilless growing medium. Such fertilizers should contain at least 50 percent of their nitrogen as nitrate-N and should contain only a minimal amount of urea. In addition to using the correct fertilizer material, proper fertilization requires an accurate estimation of fertilizer solution concentration to ensure that seedlings are not injured by excessive fertilizer salts. The amount of fertilizer necessary for a float bay is determined by the volume of water in the bay, the fertilizer analysis, and the desired nutrient level of the float bay. Additional information on fertilization is presented on page 13.

6. Water Quality

Water quality is a critical factor to consider with greenhouse production. Although water sources across the flue-cured tobacco producing area of Virginia pose little difficulty for most growers, scattered cases of water quality problems have occurred for some growers. The only means of predicting such problems is through water testing. When growers have water analyzed, they should have the results interpreted for plant production properties rather than as drinking water.

7. Clipping

Clipping is an essential management practice for direct-seeded greenhouse tobacco production. Begin clipping when plants are at least 2 inches to the bud. If seedling growth is unusually uneven, earlier clipping will allow smaller plants to catch up. Research conducted in Virginia indicates that the timing of the first clipping, the severity of clipping, and the number of total clippings does not have a significant impact on the stem diameter of the transplants. However, the above factors were important in controlling the growth rate of the seedlings and the size of the field-ready transplant. Very early clipping (1.5 inches to bud or less) resulted in shorter than desired transplants.

Suggested Clipping Program

- Begin clipping when plants are 2 to 2.5 inches tall (bud height).
- Set mower blade at 1 to 1.5 inches above the bud.

- Clip on a three-day interval between the first three clipping dates and every five days thereafter.

Plant clippings must be collected to reduce the likelihood of disease development and spread throughout the entire greenhouse. **The mower used to clip plants should be thoroughly cleaned and sanitized with a 50 percent chlorine bleach solution following each use**.

The above description of greenhouse tobacco transplant production is greatly abbreviated. Additional information is available from your local Extension agent and is detailed in *Float Greenhouse Tobacco Transplant Production Guide*, Virginia Cooperative Extension publication 436-051.

Float Fertilization Programs

The suggested fertilization schedule for greenhouse tobacco transplant production has been changed for recent seasons. This is the result of research trials conducted the past year and extensive observation of grower greenhouses over the past several years. Such a change was warranted due to the relatively high fertilizer charge of the brands of greenhouse mixes that have gained in popularity in recent years. Furthermore, some of the newer, popular flue-cured tobacco varieties have a tendency for slow and uneven seedling emergence making them more subject to injury from fertilizer salts. The new suggested fertilizer program is intended to reduce the potential of excessive fertilizer salts build-up while not impacting early seedling growth.

Suggested Greenhouse Tobacco Fertilization Schedule

1. 150 ppm N added 1 to 5 days after seeding

followed by

2. 100 ppm N added 4 weeks after seeding

The total of both applications is the equivalent of 250 ppm N based on the original depth of water in the bay (usually 4 inches). For example: using a 16-5-16 fertilizer, a total of 20.8 oz per 100 gal. (250 ppm N) would be needed with 12.5 oz per 100 gal. (150 ppm N) for the first application and 8.3 oz per 100 gal. (100 ppm N) for the second. Under normal conditions, no additional fertilizer beyond the total of 250 ppm N should be necessary. However, if the greenhouse season is prolonged due to early seeding or late transplanting, a late-season addition of 75 to 100 ppm N may be needed to maintain adequate seedling nutrient levels.

The primary drawback of delaying fertilization until after the trays are floated is the difficulty in adequately mixing the fertilizer throughout the entire float bay. To ensure even mixing of fertilizer throughout the float bay: dissolve fertilizer in buckets of water, add fertilizer at several locations throughout the bay, and use pumps to circulate water and distribute the fertilizer throughout the bay. Handheld conductivity meters (e.g. DiST4 or TDR Tester 4) are excellent tools to verify that fertilizer is evenly mixed throughout the entire float bay and that the desired concentration is obtained. The nutrient solution should be checked in several locations along both the center walkway and side curtains.

Growers accustomed to using fertilizer injectors can continue to do so with the above fertilizer schedule. The most practical method would be to add fertilizer to the bay one to three days after seeding with adequate mixing in the bay water. The injector would be used to add **125 ppm N** with each later addition of water to the bay. An alternative would be to fill bays to initial depth of 2 in. and allow trays to wick. The following day, bays would be filled to a depth of 4 in. injecting a 300 ppm N fertilizer solution for a final concentration of 150 ppm in the bay. Later additions of water would contain a concentration of 125 ppm N through the injector.

Calculation of Water Volume and Fertilizer Concentration

1. The number of gallons of water in a float bay may be calculated by:

$$\text{length (ft)} \times \text{width (ft)} \times \frac{\text{depth (in)}}{12} \times 7.48\ \text{gal/ft}^3$$

Example: $96\ \text{ft} \times 16\ \text{ft} \times \frac{4\ \text{in}}{12} \times 7.48 = 3829\ \text{gal}$

2. The amount of fertilizer required per 100 gal of water is calculated by:

$$\frac{\text{desired nutrient concentration (ppm)}}{\text{nutrient content of fertilizer (\%)}} \times 1.33$$

Example: $\frac{150\ \text{ppm N}}{16\%\ \text{N}} \times 1.33 = 12.5\ \text{oz per 100 gal}$

Usable Greenhouse Transplant Yield Research

The impact of seed, media, and fertilization on the yield of usable transplants was investigated in research trials conducted on-farm and at the Southern Piedmont AREC. The timing of initial float bay fertilization

(150 ppm N) was found to have the greatest impact on usable transplants. Fertilization at seeding resulted in an average seedling mortality of 15 percent compared to 6 percent where fertilizer was added three days after seeding. Delaying fertilizer addition resulted in 5 percent to 15 percent more usable transplants, depending on the particular seed and media combination. The primary benefit of adding fertilizer after trays are initially floated is to minimize the accumulation of excessive fertilizer salts in the media. Seedling mortality observed during the third week after seeding is frequently a result of excessive fertilizer salts. Fertilization was not found to impact the occurrence of spiral-root seedlings. Seed, media, and the interaction of these two factors were related to the account of spiral-root seedlings.

An on-farm greenhouse trial conducted in 2002 investigated the impact of three production practices on usable transplant yield. These included the use of primed seed (NC 71), covering seed with AGRIMATE, and the timing of initial fertilization. Results are shown below:

Table 3. Usable transplant yield resulting from three different greenhouse production practices.

		Usable Transplants (%) Fertilization Timing[2]	
NC 71 seed	Seed covering[1]	at seeding	3 DAS
Primed	No	88.3	90.5
Primed	AGRIMATE	87.4	90.8
Non-primed	No	83.2	90.3
Non-primed	Yes	84.9	89.6

[1]AGRIMATE applied at 0.15 g per cell.

[2]Fertilization timing, 150 ppm N added at seeding or three days after seeding (3 DAS).

Both primed and nonprimed seed of NC 71 exhibited excellent seedling emergence with minimal spiral-root seedlings. As a result, neither priming nor covering seed with AGRIMATE had a significant impact on usable transplants. The single most important factor was delaying the addition of fertilizer from seeding to three days after seeding. Increases in usable transplants ranged from 2 percent to 7 percent by delaying fertilizer addition until three days after seeding.

Fertilization

The application of adequate amounts of the proper nutrients is necessary for profitable tobacco production. Either under- or over-fertilization may result in a crop of unsatisfactory quality and reduced value. Excessive use of fertilizer is an unnecessary production cost and may have adverse environmental impacts. Proper fertilization may be at more of a premium than in recent years as contract tobacco purchases place specific requirements on the quality of tobacco. Unripe tobacco will be severely discounted or perhaps refused. The principles of tobacco fertilization have been established by decades of research.

Soils differ in productive capacity and fertility level. Therefore, careful attention must be given to the physical and chemical characteristics of the soil in selecting the rate and grade of fertilizer to be used. Soil tests, a history of previous crop performance, and the amount and distribution of rainfall are helpful guides in estimating the fertilizer and lime requirements for specific fields.

Soil Testing

Only through soil sampling and soil testing can the pH and nutrient status of soils be determined and the most cost effective fertilization program followed. Fields used for tobacco production should be soil sampled every three years to monitor changes in soil pH. Soil testing and following liming recommendations are critical to avoid either a low pH situation or an excessive high pH that results from over liming. Over liming can increase the possibility of certain disease problems (black shank and black root rot) and cause an imbalance of certain micronutrients. However, the most common soil fertility problem associated with tobacco producers in Virginia is excessively acid soils or low pH. In extreme cases, certain elements such as aluminum and manganese become toxic to plants while other nutrients may be deficient. The desired pH range for flue-cured tobacco is 5.7 to 6.2.

Soil pH also has a big impact on the availability to the tobacco crop of nutrients applied with fertilizers. Fertilizer efficiency is considered to be optimum at a pH of 7.0 and decreases with increased soil acidity shown as following:

	Fertilizer Efficiency		
	Nitrogen	Phosphate	Potash
7.0	100%	100%	100%
6.0	89%	52%	100%
5.5	77%	48%	77%
5.0	53%	34%	52%
4.5	30%	23%	33%

Failure to maintain a soil pH within the desirable range of 5.7 to 6.2 results in reduced fertilizer efficiency and perhaps increased fertilizer costs due to the over application of fertilizer necessary to compensate for reduced nutrient availability.

Nitrogen

Flue-cured tobacco is very exacting in its nitrogen requirement. The regulation of the amount and timing of nitrogen availability is extremely important. Inadequate nitrogen results in low yield and quality of tobacco. Excess nitrogen delays maturity and is associated with tobacco that is undesirable in color (KL, KF, GK, etc.), high in nicotine, and is of generally poor quality. Excess nitrogen will also increase sucker growth which may lead to excessive use of maleic hydrazide (MH), and increase the severity of some diseases and insect problems.

Unfortunately, there is no reliable soil testing procedure for determining nitrogen needs as there is for phosphorus, potassium, and other nutrients. It is well recognized that soils differ in their ability to hold nitrogen. Some of the more important soil characteristics affecting this are organic matter content, texture of the surface, and depth to subsoil. Previous cropping history, seasonal rainfall, and variety must also be considered in determining nitrogen rates. Fields with deeper, sandy topsoils require more nitrogen than those with shallower, heavier textured topsoils. For sandy loam soils of average fertility, suggested nitrogen rates for different topsoil depths are as follows:

Topsoil depth (in.)	Nitrogen rate (lb/A)
0 to 12	50 to 60
12 to 18	60 to 70
18 to 24	70 to 80

At least 50 percent of the total nitrogen in the base fertilizers should be in the nitrate form. Evidence from numerous experiments has not shown any superiority of natural or synthetic organics over standard inorganic sources of nitrogen for the production of flue-cured tobacco.

Adjustment for Leaching

Leaching is the loss of certain nutrients as a result of excessive water moving (percolating) through the root zone. Many producers often confuse drowning and associated root damage with fertilizer leaching. Leaching is seldom a problem on heavier textured soils or on soils with a hardpan within 10 to 12 inches of the surface. It is not uncommon for nitrogen and potassium to move down to clay and then be absorbed later as root growth continues. Adjustment for leaching in this case usually results in over fertilization and a crop that is slow to mature and difficult to cure.

When leaching does occur, the reapplication of both nitrogen and potassium may be necessary. The quantity of nitrogen and potassium required will depend on the amount of water that percolates through the plow layer and the stage of plant growth at the time this occurs. Although research information on nutrient replacement from leaching is limited, the information in Table 4 (taken from North Carolina Cooperative Extension publication AG-187) may be used as a general guide for making leaching adjustments.

Table 4. Nitrogen Adjustment for Excess Water[a]

Topsoil depth (to clay) in inches	Est. inches of excess[b] water percolated through soil	% of applied N to replace after transplanting		
		weeks		
		1-3	4-5	6-7
Less than 10	1	0	0	0
	2	20	10	0
	3 or more	30	20	0
10 to 6	1	30	20	0
	2	45	30	10
	3 or more	60	40	15
17 or more	1	50	25	15
	2	75	35	20
	3 or more	100	45	25

[a]For each pound of N used as an adjustment for leaching, use about 1 pound of potash (K_20) where recommended potash levels as a base application have been used.

[b]Excess water is that quantity percolating through the soil after the water-holding capacity of the soil has been satisfied.

Applications of fertilizer to replace elements lost through leaching should be made as soon as possible after heavy, slow rains. Waiting until deficiency symptoms develop before applying supplemental fertilizer is not recommended.

Phosphorus and Potassium

Phosphorus is probably the nutrient most used to excess in tobacco fertilization in Virginia. Repeated applications of larger quantities of phosphorus than plants can absorb, and with essentially no loss from leaching, has resulted in a general buildup of this element. Soil analyses of tobacco fields conducted by the Virginia Tech Soil Testing Laboratory indicated that approximately 97 percent of the soils had a medium or higher phosphorus level. Extensive testing in Virginia and other states has shown that on soils with a medium or high phosphorus level, 40 lbs/A of phosphorus (P_20_5) are adequate to give maximum production and maintain the soil phosphorus level. Growth responses of tobacco to phosphorus application are observed more frequently early in the growing season than they are in final yield and quality.

Potassium requirements of tobacco are relatively high, and a high potassium content in flue-cured tobacco is needed for good smoking quality. Soils vary in their supply of available potassium, depending upon the parent material, previous fertilization, and cropping history. Approximately 100 to 175 lbs/A of potash (K_20) are adequate for most soil conditions. Potassium may be lost by leaching from the root zone in extremely sandy soils.

Due to the many factors necessary to consider when making fertilizer recommendations for a particular field, data in the following table can be used only as general recommendations for phosphorus (P_20_5) and potassium (K_20).

	Pounds suggested per acre	
Soil Test Category	P_20_5	K_20
L	230*	150-175
	60-100	
M	60-100	100-150
H	40	100
VH	40	100

*Basic application; to build up soil, phosphorus may be broadcast and plowed-in or disked-in before planting. The 230 lb P205/A can be obtained from 500 lb/A of 0-46-0.

Calcium and Magnesium

If the soil pH is maintained within the desirable range of 5.7 to 6.2 with dolomitic limestone, the available levels of calcium and magnesium will generally be sufficient to meet the needs of the crop. Otherwise, 40 to 50 lb/A of Ca and about 30 lb/A of available magnesium oxide (Mg0) are needed from the mixed fertilizer.

Micronutrients

The need for the application of micronutrients such as boron, copper, manganese, and zinc has not been demonstrated sufficiently with tobacco to warrant general applications. It is definitely known that if applied at excessive rates, these elements are toxic to tobacco. Boron is the micronutrient most likely to be deficient for tobacco. Generally 0.25 lb/A of elemental boron (approximately 2.5 pounds of borax) is sufficient to correct or prevent such deficiencies.

Selecting the Fertilizer Grade

The analysis of a fertilizer gives the percentage of nitrogen, phosphorus (P_20_5), and potassium (K_20) contained in the material. Complete fertilizer grade ratios ($N:P_20_5:K_20$) available for use on tobacco in Virginia are as follows: 1:3:3 (3:9:9); 1:2:3 (4:8:12, 5-10-15, 6-12-18, and 8-16-24); and 1:1:3 (6-6-18 and 8-8-24). The analysis determines the amount of nutrients supplied. For example, 6-12-18 supplies 6 pounds of nitrogen, 12 pounds of phosphorus (P_20_5) and 18 pounds of potassium (K_20) for each 100 pounds. The basic difference among the three available ratios is that they supply different amounts of phosphorus relative to nitrogen and potassium. Selection of the complete fertilizer grade should be based on the phosphorus (P) soil-test level. On soil testing high (H) to very high (VH), only a 1:1:3 fertilizer analysis should be used. A 1:2:3 analysis fertilizer should only be used for soils testing medium (M) or less for phosphorus. Very few fields used for tobacco production would have a low (L) phosphorus test level and thus warrant the use of 1:3:3 grade fertilizer.

The preplant fertilizer should supply approximately 40 lbs/A of N and 120 lbs/A of K_2O. Additional N and K_20 can be applied as a side application to obtain the total amount of nutrients desired. The soil test recommendation for potassium should be used as a guide in selecting the sidedress fertilizer. If no additional potash is recommended above that supplied in the complete fertilizer, a 1:0:0 analysis sidedress should be used to supply only nitrogen. Calcium nitrate (15.5-0-0) should be considered as an alternative to nitrate of soda. Calcium nitrate supplies 19 percent calcium. Liquid nitrogen solutions may also be used but equipment to apply liquid fertilizer is required and the materials should be incorporated to prevent loss to volatilization. If additional potash is necessary, then a 1:0:1 sidedress may be used to supply both nitrogen and potash. The primary N and potash products are 13-0-14 and 14-0-14. Fertilizer containing phosphorus should not be used as sidedresses since the late-applied phosphorus is not necessary for the crop and the cost of the fertilizer is more than a conventional sidedress products.

The practice of blending a complete fertilizer (NPK) with a sidedress fertilizer and working a single application is discouraged. Blending two dissimilar fertilizer products can result in a lack of uniformity. Furthermore, a single early application of fertilizer subjects all to potentially leaching rains and makes any necessary adjustment more difficult. Split application of a complete fertilizer and a sidedress provides the nutrients to the cop when they are needed and the grower has greater control over the availability.

Growers are strongly encouraged to soil test fields before tobacco is planted in the rotation, follow liming recommendations, and select a complete fertilizer grade based on phosphorus soil-test levels. Doing so will ensure optimum fertilizer efficiency, avoid unnecessary fertilizer expense, and reduce excessive phosphorus application that can have a negative environmental impact.

Sidedress Fertilizer Evaluation

Growers have lost two popular sidedress fertilizer products in recent years, mainly 16 N nitrate of soda and 15-0-14. Tests were conducted in 2006 to investigate available sidedresses. Data from the test conducted at the Southern Piedmont AREC are reported in Table 5.

The soil test for potash for the test site indicated that no additional potash was necessary with sidedress application. All sidedress treatments were applied at the rate to provide and additional 28 lbs/A of N. Final rates of potash varied according to the sidedress materials, as well as calcium and magnesium. K-Mag was applied at x lbs/A to supply 28 lbs/A of potash, comparable to treatment applied with the 14-0-14 treatment.

Table 5. Agronomic results of a sidedress fertilizer comparison conducted at the Southern Piedmont AREC in 2006.

Sidedresses	Yield (lbs/A)	Grade Index	Price ($/lb)
13-0-14	3892	87.3	1.47
14-0-14	3736	86.0	1.46
15-0-14	3614	85.0	1.43
15.5-0-0	3408	86.7	1.45
CN-9	3213	88.0	1.47
UAN-30	3872	85.3	1.44
CN-9 plus K-Mag	3459	87.0	1.47
UAN plus K-Mag	3552	88.0	1.48

Complete fertilizer was band after transplanting at a rate of 750 lbs/A to supply 45 lbs/A N and 135 lbs/A of potash.

Yield results were variable, possibly due to excessive rainfall that occurred and no significant differences were observed between the treatments. Average price and grade index were more consistent and do not show any practical difference among the treatments. Results of these show the sidedress treatments to be equal and the decision to choose between them should be based on cost, ease of application, and past experience.

Transplant Starter Solutions

The benefit of a high-phosphorus starter fertilizer in the transplant setter water results from the ready availability of P at the stage in crop development when P may be most limiting. Transplant starter fertilizers should contain a greater proportion of P_2O_5 than N and potash (i.e. 10-52-8, 9-45-16, 12-48-8, etc.) and research has shown a rate of 5 lbs/A ofP_2O_5 to be sufficient and not expected to result in crop injury. The use of high P transplant starter fertilizer can be expected to provide more rapid and more even early season growth that ultimately results in earlier more uniform topping. However, these effects do not persist through harvest and no yield response should be expected. The results of a comparison of transplant starter fertilizers are described in tables below. The test evaluated starter fertilizers using both plant-bed and greenhouse-grown transplants. Treatments tested included:

Trt. No.	Product	Analysis	Application rate
1	Untreated	--	--
2	Exceed	10-10-10	2 qts/A
3	Jump-Start	8-31-4	2 qts/A
4	Charge	8-32-5	2 qts/A
5	Pro-Sol	10-52-8	10 lbs/A
6	Miller	12-48-8	10 lbs/A

The products tested differ in analysis (N:P:K) and no attempt was made to apply similar nutrient levels with each product. Products were applied at suggested rates; and therefore, nutrient levels are not equal among the treatments.

Measurement of plants in the field indicated that Treatments 3 to 6 (high P) resulted in more rapid early-season growth than observed with the low P fertilizer (Treatment 2) or untreated plants (Treatment 1). As plants neared topping stage, differences between the treatments tended to diminish. However, plants in Treatments 3 to 6 did come into top earlier than those in Treatments 1 and 2. There was no apparent difference in the response of plant-bed and greenhouse-grown transplants to the fertilizers. Such early-season growth responses did not result in any significant difference in the yield of the treatments for both plant-bed and greenhouse transplants (see Table 6).

Table 6. Topping and yield data for six transplant water treatments applied to plant-bed and greenhouse-float transplants, Southern Piedmont AREC, 1993.

Starter fertilizer	Percent of plants topped by July 19		Yield (lbs/A)	
	GH	PB	GH	PB
Untreated	33	30	3456	3471
Exceed	23	30	3365	3400
Jump-Start	69	88	3094	3424
Charge	59	64	3440	3525
Pro-Sol	81	88	3122	3399
Miller	86	59	3169	3356

GH = greenhouse
PB = plant bed grown transplants

Crop Rotations and Cover Crops

Crop rotation is one of the most effective and inexpensive methods known to increase the efficiency of flue-cured tobacco production. Crop rotation improves soil structure and nutrient balance, increasing the efficiency with which tobacco plants can utilize fertilizer and soil water. Continuous tobacco culture, even in the best of fields, promotes soil erosion and loss of soil structure, which will eventually reduce the capacity of plants in such fields to obtain enough plant food and water for maximum production. In addition, crop rotation is an excellent practice for control of tobacco diseases, insects, and weeds. Not only does crop rotation reduce losses in yield and quality to these pests, but it also reduces the need for expensive pesticides, thus reducing production costs. Crop rotation can, therefore, increase net economic returns to producers by increasing the yield and quality from each field **and** by reducing the costs of producing flue-cured tobacco.

Special attention should be given to the crop immediately preceding tobacco in the rotation. For example, leguminous crops should not immediately precede flue-cured tobacco because the amount of nitrogen from the crop and the time of its availability varies widely and the following tobacco crop may be affected.

The conservation compliance provision of the Food Security Act of 1985 discourages production of crops in highly erodible fields where the land is not carefully protected from erosion. If crops are produced in such fields without an approved soil conservation system, producers may lose their eligibility for certain U.S. Department of Agriculture program benefits. Contact your local Natural Resources Conservation Service (NRCS) office for more information or for soil conservation planning assistance.

Some examples of rotation plans commonly used in the flue-cured tobacco producing area of Virginia include:

- **1-year rotation**
  tobacco followed by small-grain or ryegrass cover crop

- **2-year rotation**
  1st year - tobacco followed by small grain and fescue or ryegrass
  2nd year - grass

- **2-year rotation**
  1st year - tobacco followed by small grain

2nd year - small grain cut for silage and followed by grain sorghum followed by a winter cover crop

- **3-year rotation**

  1st year - tobacco followed by small grain and fescue

  2nd year - grass

  3rd year - grass.

Seed beds for cover crops should be medium smooth, but not level. Small grains, or a combination of small grains and a grass, should be seeded as soon as possible after the second disking of tobacco roots. Early seeding of the cover crop is important to allow the cover crop to grow as much as possible during the fall. The soil surface should allow a maximum number of tobacco roots to remain exposed, even after seeding the cover crop. Crops and seeding rates for common cover crops are: RYE or WHEAT - 1 to 1 1/2 bu/A; BARLEY - 2 to 3 bu/A; DOMESTIC RYEGRASS - 20 to 25 lb/A.; TALL FESCUE - 15 to 20 lb/A.; SORGHUM-SUDAN HYBRID - 25 to 30 lb/A; GRAIN SORGHUM - 5 to 7 lb/A. When seeding with small grains, the seeding rate for ryegrass and fescue should be reduced to 15 lb/A.

Cover crops should be plowed under while still young and succulent, generally from mid- to late-March. Temporary nitrogen deficiency, as well as other problems, may be encountered if cover crops are plowed under late in the spring after the plants within the cover crop have become tall and woody. If the sod of the cover crop is dense, it may be necessary to disk thoroughly in order to tear up the sod prior to plowing.

Sucker Control

Topping

Tobacco should be topped when 40 to 50 percent of the plants reach the elongated button stage of flowering. Remaining plants should be topped as early as practical after they reach the button stage. Allowing tobacco to remain untopped for up to three weeks after reaching the button stage will reduce yields 20 to 25 lbs/A per day. Late topping also increases the chance of plants blowing over in a windstorm.

The height at which to top the plants will depend primarily on seasonal conditions, variety, and, to some extent, on the fertility level of the soil. Optimum leaf number is generally in the range of 18 to 22 leaves per plant.

Chemical Sucker Control

Three types of chemicals are currently available for sucker control. Growers should have a basic understanding of how the various chemicals work in order to most effectively use them.

1. **Contacts** (fatty alcohols) quickly kill suckers by burning and must come in contact with the suckers to be effective. Suckers should begin to turn brown within an hour of contact application. A sufficiently concentrated solution of contact material is required to obtain adequate sucker control. Use a 4 percent solution or 2 gallons in 48 gallons of water.

   The strength of a contact fatty alcohol product depends on carbon chain length of the fatty alcohols. Products traditionally used in Virginia are a mixture of C_6, C_8, C_{10}, and C_{12} alcohols while products containing only C_{10} alcohols are available. To avoid possible injury, C_{10} products should be used at lower concentrations than mixed alcohol products (3 percent and 4 percent concentration of a C_{10} product would be comparable to 4 percent and 5 percent concentration of a mixed alcohol product, respectively).

2. **Systemic sucker control chemicals** or maleic hydrazide (MH) restrict sucker growth physiologically by stopping cell division. The only growth made after MH is applied is in the expansion of cells already present in the plant. To reduce MH residues on the cured tobacco, **no more than one application of the labeled rate of MH may be applied per season**. **Wait at least one week between MH application and harvest**.

3. Products that have a **local systemic** mode of action (Flupro and Prime+) stop cell division in a localized area and must wet the sucker buds in each leaf axial to be effective. The materials have no true contact activity and do not turn the sucker black. Affected suckers will have a yellow, deformed appearance.

Precautions with contacts:

1. Control is achieved when suckers are small (not over one inch long).

2. Never spray foam from tank; this will increase the likelihood of burning leaves.

3. Do not spray extremely succulent tobacco (tobacco with a light green to creamy white bud area). This indicates a fast rate of growth.

4. Rain within an hour after application of contacts may reduce their effectiveness.

5. In order to kill both primary and secondary suckers, contact solutions should not be applied at concentrations less than 4 percent. It may be necessary to increase the concentration to 5 percent when applications are made under cool overcast weather conditions.

Precautions with local systemics:

1. Rain occurring within two hours after spraying may reduce effectiveness.

2. Applications to leaning plants, wet plants, or wilted plants may reduce effectiveness.

3. Applications made before the elongated button stage of growth may result in chemical topping or distortion of leaves that were too immature at time of application.

4. Sucker buds must be directly contacted to obtain control. Control is reduced if suckers are allowed to grow too large (greater than 1 in.) before application.

5. Prime+ carryover residues may injure small grains and corn, and has been reported to stunt early-season growth of tobacco when used with dinitroaniline herbicides such as Prowl. Fall disking and deep tillage are suggested to mitigate this potential.

Precautions with systemics:

1. Do not apply during the hot part of the day when leaf stomata are closed.

2. Rain within six hours after application of MH may reduce control. Research has shown that if a significant rain occurs more than three hours after application, only a half rate of MH (0.75 gal/A) should be reapplied to maintain good sucker control.

EPA Worker Protection Standards

Read and follow all label directions regarding EPA Worker Protection Standards (WPS). Growers must follow requirements for personal protective equipment (PPE) and restricted-entry intervals (REI). Hand topping following an over-the-top contact application provides the best level of sucker control since the top serves to funnel the material down the stalk to contact each leaf axil. However, hand topping within the restricted-entry interval means that workers must wear all required PPE to comply with WPS. Likewise, hand application of sucker control chemicals and topping are impacted by the PPE requirements. Growers are also responsible for instructing early-entry workers on how to prevent, recognize, and give correct first aid for heat illness (too much heat stress).

MH Residues

Virginia's flue-cured tobacco has traditionally had some of the lowest MH residue levels in the United States and this has been a factor contributing to the traditional quality of the crop. Much of the low-residue nature of the crop has been a consequence of having a significant portion of the acreage treated by hand with Prime+ and similar products. In many cases, this tobacco is not treated with any MH or may be treated with a reduced rate of MH. For tobacco that is treated with MH in a more typical fashion (over-the-top sprays of two contact fatty alcohols followed by MH), there has generally not been a high proportion of samples with excessive residue levels. However, there is always the occurrence of some samples with excessive residues. There are several factors that impact MH residues: the rate, number, and timing of MH applications as well as weather and crop conditions. Leaf dealers and cigarette manufacturers remain concerned with MH residues and this is heightened with international markets. A contract marketing system lends itself to more rigorous sampling programs and traceability of the tobacco sold.

The high cost of labor and issues related to worker exposure to pesticides make the practice of hand application of sucker control problematic and growers should examine the practice given their specific circumstances. Unfortunately at the present time, the only alternative to hand application are the sequential sucker control programs with over-the-top foliar sprays of contact fatty alcohols followed by MH. However, growers must remain vigilant in minimizing MH residues in the cured tobacco.

Guidelines for Effective Sucker Control Practices to Minimize MH Residues

1. Make only one application of the labeled rate of MH-30 (2.25 lbs ai/A). Do not make split

applications of MH even at reduced rates since the second application will likely increase residues present in later harvests.

2. Observe the preharvest interval (seven days) following MH application.

3. Consider the addition of a dinitroaniline product such as Prime+ or Flupro to the typical sequential sucker control program. These products may be tank mixed with or substituted for the last contact fatty alcohol before MH, or tank mixed with MH, or applied alone after MH (usually three to four weeks later). The rate of either Prime+ or Flupro would be 1 to 2 qt/A. The 2-qt rate has been the most thoroughly tested and has been very effective will applied as describe above.

4. Maximize the effectiveness of contact fatty alcohols by limiting excessive growth prior to their application. It is important to make the first application before pretopping suckers have grown significantly (not more that 1 in. long). Large pretopping sucker may require hand clean-up. The first application of a C8 / C10 fatty alcohol mixture should be made at a 4 percent concentration (4 gallons fatty alcohol to 96 gallons of spray material water) and later applications should be made at 5 percent (5 gallons per 95 gallons).

5. The use of coarse spray tips (TG3-TG5-TG3) and low pressure for MH applications result in coarser droplets that result in less wetting of the underside of the leaves and thus MH is not as readily dissipated by rainfall and dews.

6. Don't add spray surfactants to MH applications. Product labels for MH do not state either their usefulness or necessity. The wide variety of surfactants available has not been sufficiently tested with MH to be able to predict the response in MH residue levels. A potentially positive response in rainfastness could be offset by excessive MH in the cured leaf.

Suggested Sucker Control Programs

Program I. Sequential Method

1. Apply contact sucker control chemical (4-percent concentration) before topping when approximately 50 percent to 60 percent of plants reach the button stage. A small percentage of plants should be chemically topped by this application.

2. A second contact application (5-percent concentration) should be made three to five days after the first. Fields having irregular growth may require an additional application (5-percent concentration) five to seven days later. Top remaining plants that were not topped originally.

3. About five to seven days after the last contact, apply one of the following alternatives:

   a) MH (**only one application per season**); or

   b) FST-7, Leven-38 or a contact and MH tank mix; or

   c) tank mix of MH with Flupro or Prime+

   d) apply Flupro or Prime+ (1 gal/A)

4. Prime+ may be substituted for the second contact application (or third, if field has irregular growth) and followed with a labeled rate of MH about 1 week later.

5. If control of late season sucker growth is necessary, one of the following alternatives may be applied three to four weeks after MH application:

   a) Flupro or Prime+; or

   b) 5-percent concentration of contact material

Program II. Individual Plant Method with a Dinitroaniline

Apply Flupro or Prime+ with a dropline, backpack, or jug when plants reach the elongated bud stage. Usually two or perhaps three trips are required to remove tops and treat all plants in a field. Individual plants should not be treated more than once. **Growers are reminded to comply with all label directions regarding worker protection standards (WPS).**

Sucker control in Virginia is highly dependent upon the hand application of local systemic chemicals such as Prime+ or Flupro. The reliance on the hand application of these chemicals to individual plants has been considered necessary due to the rolling landscape in Southside Virginia and the layout of fields to fit the landscape. Whether applied with jugs or with droplines, hand application of sucker control chemicals is problematic in regard to worker exposure to pesticides and issues related to worker protection standards (WPS). Complying with PPE requirements for WPS is challenging for the hand application of sucker control chemicals.

For the past several years, on-farm trials have been conducted to evaluate tractor-spray applications of sucker control and compare these to hand-applied treatments. These results have been reported annually in this production guide and have demonstrated the potential of over-the-top application for sucker control in Virginia. With proper planning and application technique, over-the-top sucker control programs can be used by the large majority of tobacco growers in Virginia, thus eliminating the necessity of hand application.

In order for over-the-top sucker control applications to be effective, the chemicals must be applied correctly. Contact fatty alcohols and local systemics must contact the growing sucker bud at every leaf position on the stalk. Therefore spray nozzles must be directly over the tobacco plants, making uniform row spacing throughout the entire field extremely important. Spray rows must be kept in good condition to allow for uniform travel speed and to minimize rough conditions that will cause excessive bouncing of the spray boom.

Historically, three hollow-cone nozzles arranged with a TG-5 in the center and a TG-3 on either side have been used for contact sucker control applications. With a spray pressure of 20 psi, a desired application rate of 50 gpa is obtained with a travel speed of approximately 3.8 mph. This speed is too fast for many field conditions in Virginia thus impacting the level of sucker control obtained. Using smaller spray tips, the desired application rate can be obtained at a reduced travel speed. Doing so will improve sucker control by allowing the spray operator to deliver the spray material to every plant and hopefully contacting every leaf axil. The following table gives the spray application rate (gpa) obtained from five different spray tip arrangements across a wide range in travel speeds. An application rate of 50 gal/A is optimal, higher rates will increase contact fatty alcohol usage and lower rates will reduce spray effectiveness (maintain at least 45 gal/A).

Sucker Control Spray Tip Options

Table. 7. Spray application rate with four different spray-tip arrangements over a range in travel speeds, calculated based on 48-in. row spacing and 20 psi spray pressure.

	Spray tip arrangement (3 tips per row)			
Speed (mph)	**TG-3 (2) TG-5**	**TG-3 (2) TG-4**	**TG-2 (2) TG-4**	**TG-2 (2) TG-3**
	gallons per acre			
2.0	93.4	84.8	68.7	60.0
2.2	84.9	77.1	62.4	54.6
2.4	77.9	70.6	57.2	**50.0**
2.6	71.9	65.2	**52.8**	46.2
2.8	66.7	60.5	**49.1**	42.9
3.0	62.3	56.5	45.8	40.0
3.2	58.4	**53.0**	42.9	37.5
3.4	55.0	**49.9**	40.4	35.3
3.6	**51.9**	47.1	38.2	33.3
3.8	**49.2**	44.6	36.1	31.6
4.0	46.7	42.4	34.3	30.0
4.2	44.5	40.4	32.7	28.6
4.4	42.5	38.5	31.2	27.3
4.6	40.6	36.9	29.9	26.1
4.8	38.9	35.3	28.6	25.0
5.0	37.4	33.9	27.5	24.0

Calibration of a sprayer using the 1/128th acre method is relatively easy. Using this method for a row spacing of 48 inches, the travel time with a tractor in the field is recorded for a distance of 85 feet. Collect water from the spray tips at operating pressure for the length of travel time (85 feet. The amount of water collected from all three nozzles of one row is equal to the spray application rate in gallons per acre (gal/A). The travel time for the 85-foot calibration distance increases from 16 seconds for 3.6 mph to 22 seconds for 2.6 mph. Detailed information on using the 1/128th acre method of calibration and determining travel speeds is available from your local Extension agent.

On-Farm Sucker Control Tests

Each year a number of sucker control tests are conducted on-farm across the flue-cured tobacco production area of Virginia. The objective of these on-farm tests is to demonstrate the feasibility of using tractor-mounted sprayers to apply sucker control chemicals, thus eliminating the expense of hand-application methods and reducing worker exposure to pesticides. These tests are conducted in typical grower fields and applications are made to three or four rows, depending on field arrangement. In 2004, all applications are made at a spray volume of 50 gal/A, using three nozzles per row of 2 TG-2 with a TG-4 in the center at a pressure of 20 psi. Tractor speed was approximately 2.8 mph. Sucker control is evaluated by counting the number and weight of suckers per 100 plants in each plot and determining the percentage of plants with no suckers (clean plants). Results of the tests illustrate the benefit of adding dinitroaniline such as FluPro in combination with MH. Sucker control was significantly improved with treatments 2 and 3 compared to 1. The dinitroaniline may also be substituted for the second contact application (treatments 4 and 5). A MH-free alternative was included as treatment 6 with the application of FluPro at the normal timing of MH application. Although the results in 2004 with treatment 6 were acceptable, results with such MH-free treatments are very dependent upon the season and the spray application conditions. Previous research has shown that FluPro and Prime+ are interchangeable as dinitroaniline products.

A test conducted in 2005 looked at the addition of Prime+ to malaic hydrazide or MH treatments and compared these to a dropline application of Prime+. Royal MH-30 was compared with FST-7 which is a mixture of MH contact fatty alcohol. All of the treatments except the Prime+ dropline application (treatment 7.) followed two applications of contact fatty alcohols of 4 percent and 5 percent. Results indicate that the addition of Prime+ (treatments 2, 3, and 5) improved sucker control compared to no Prime+ (treatments 1 and 4). The level of control obtained with the Prime+ dropline application (treatment 7) was not as good as it should have been due to a failure to ensure application to the uppermost leaf axils. Suckers that were not controlled by the chemical treatments were not cleaned-up but remained in the field until harvest completion.

Table 8. Average results of three on-farm sucker control tests conducted in Virginia in 2004.

	Sucker Control Treatment[2]			Sucker control at end of season[1]		
				Suckers per 100 plants		
Trt no.	at topping	3 to 5 days later	1 week later	no.	wt. (lbs)	Clean plants (%)
1	FA 4%	FA 5%	RMH-30 1.5 gal/A	90.7 b	33.8 a	52.0 b
2	FA 4%	FA 5%	RMH-30 1.5 gal and FluPro 2 qt/A	48.7 a	13.5 b	84.0 a
3	FA 4%	FA 5%	RMH-30 1.0 gal and FluPro 2 qt/A	47.3 a	14.2 a	85.3 a
4	FA 4%	FluPro 2 qt/A	RMH-30 1.0 gal	63.3 a	5.4 b	86.0 a
5	FA 4%	FluPro 2 qt/A	RMH-30 1.5 gal	52.0 a	21.6 ab	84.0 a
6	FA 4%	FA 5%	FluPro 3 qt/A	54.7 a	15.2 ab	82.0 a

[1]Means followed by the same letter are not significantly different.

[2]FA = contact fatty alcohol (Off-Shoot T was used in these particular tests both other products could be substituted with similar results)

Table 9. Results of chemical sucker control test conducted in Henry County in 2005.

Trt. No.	Systemic Sucker Control Application Following Contacts	Suckers per 100 plants no.	Suckers per 100 plants wt. (lbs)
1	RMH-30 1.5 gal	39	7.0
2	MH-30 1.5 gal with Prime+ 2 qt 4 weeks later	4	0.3
3	RMH-30 1.5 & Prime+ 2 as a tank mix	4	1.5
4	FST-7 3 gal	50	11.9
5	FST-3 3 gal & Prime+ 2 qt tank mix	10	3.3
6	Hand application (droplines) Prime+ 2%	26	9.6

Results from a sucker control test conducted at the Southern Piedmont AREC in 2007 are presented in Table 10. This set of treatments is a part of a larger test conducted to evaluate reduced MH and MH-free treatments. Results are expressed in terms of percent sucker control which is calculated based on the weight of sucker compared to a treatment receiving no chemical sucker control (topped-not-suckered). All treatments were applied using two TG-3 tips and one TG-5 over the center of the row, except treatments 5 and 8. These treatments were applied with two TG-2 tips and a TG-6 to direct a greater proportion of the spray material directly over the plant stalk (60 percent compared to the typical 47 percent with the TG-3's and 5). Travel speed was reduced slightly to provide for the same application rate (50 gpa) with the two spray tip arrangements. The two treatments with 1.5 gallons of MH-30 (2.25 lbs ai/A) provided the poorest sucker control at approximately 30 percent. The tank mix of 1.5 gallons MH-30 and 2 qt/A of the dinitroaniline, Flupro, significantly improved sucker control to greater than 90 percent. Similar levels of control were obtained from treatments with reduced rates of MH in combination with Flupro (treatments 1 and 4). Omitting MH entirely and applying 2 qt/A of Flupro (treatments 5 and 6) did not provide satisfactory control when applied once, but when split in two applications of 1 qt each (treatment 2) did provide excellent control. The third and fourth spray applications in this test were separated by 18 days with the first harvest occurring during this time. No differences were observed among treatments comparing applications using TG-3s and a 5 with TG-2s and a 6. Results of the tests reinforce the fact that the tank mix of 1.5 gallons MH-30 with 2 quarts of a dinitroaniline is the standard for sequential sucker control. The results also show promise with regard to the possibility of reducing the rate of MH when used in conjunction with a dinitroaniline (treatments 1 and 4). These and similar reduced MH or MH-free treatments need to be evaluated further under a wider range of conditions to ensure their reliability. Reducing or eliminating the systemic control obtained from MH will require greater management to ensure satisfactory results from dinitroanilines. The proper application technique and timing will be critically important to minimize the growth of escape suckers that can occur.

Table 10. Reduced MH and MH free sucker control test conducted at the Southern Piedmont AREC, Blackstone, 2007.

Trt. No.	Application 1st	Application 2nd	Application 3rd	Application 4th	Percent Sucker Control[1]
1	FA[2] 4%	FA 5%	Flupro1 qt	MH-30 & Flupro 3 qt and 1 qt	97.9 a
2	FA 4%	FA 5%	Flupro 1 qt	Flupro 1 qt	96.6 a
3	FA 4%	FA 5%	MH-30 & Flupro 1.5 gal and 2 qt		91.5 a
4	FA 4%	FA 5%	Flupro 2 qt	MH-30 1 gal	90.0 a
5	FA 4%	FA 5%	Flupro 2 qt	*(**2 TG-2 and 1 TG-6**)*	69.4 b
6	FA 4%	FA 5%	Flupro 2 qt		66.9 b
7	FA 4%	FA 5%	MH-30 1.5 gal	*(**2 TG-2 and 1 TG-6**)*	32.1 c
8	FA 4%	FA 5%	MH-30 1.5 gal		28.0 c

[1]Percent sucker control values followed by the same letter are not significantly different.
[2]FA= contact fatty alcohol (Sucker Plucker was used in this test but other products could be substituted with similar results).

Suggestions for application of sucker control materials

Product Type	When to Apply	Application Rate
Contacts (fatty alcohols)	1. 1^{st} appl. at 50% elongated button 2. 2^{nd} appl. 3 to 5 days after 1^{st} appl. 3. Late season application 3 to 4 weeks after MH, if needed	1^{st} application as a 4% solution or 2 gal in 48 gal of water 2^{nd} application as a 5% solution or 2.5 gal in 47.5 gal of water C_{10} products are applied at 3 and 4% for the 1^{st} and 2^{nd} applications, respectively
Application Procedure **Power Spray** 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3s) Apply 50 gal of spray material per acre **Hand Application** 20 psi max. and ½ to $^2/_3$ fl oz per plant		
Local systemics (Flupro and Prime+)	1. Individual plants at elongated button stage (dropline or jug application) 2. 5 days after 1^{st} contact application 3. Late season application 3 to 4 weeks after MH ,if needed	**Power Spray** 2 qt/A of Flupro or Prime+ Apply 50 gal of spray material per acre. **Hand Application** 2% solution or 1 gal in 49 gal of water (2.5 fl oz of Flupro or Prime+ per gal of water). Do not apply more than 30 gal of spray per acre
Application Procedure **Power Spray** 15 - 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3s) **Hand Application** Coarse spray (20 psi and TG-3 or 5 nozzle) or drench using jugs and apply ½ to $^2/_3$ fl oz per plant depending on height		
Systemics (MH)	When used as part of sequential control program - apply 1 week after 2nd contact application.	2.25 to 3.0 lb of MH (1.5 to 2 gal of 1.5 lb/gal product) (1 to 1.33 gal of 2.25 lb/gal product) Apply 40 to 50 gal of spray material per acre.
Application Procedure Apply as a coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3s) and 20 to 25 psi or as a fine spray using 3 hollow cone nozzles per row (i.e. 2 TX-26 and 2 TX-18) and 40 to 60 psi. Direct spray toward upper third of the plant.		
Tank mix of MH with Flupro or Prime+	When used as part of sequential control program - apply 1 week after 2nd contact application.	2.25 to 3.0 lb MH with 2 qt/A of Flupro or Prime+ Apply 50 gal of spray material per acre.
Application Procedure Apply as coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3's) and 20-25 psi.		

Chemical Coloring Agents

Ethy-gen, Livingston Tobacco Curing Gas, and ethephon are products reputed to aid in "coloring" tobacco and reduce the yellowing time during curing. Growers should not expect these products to solve problems such as ripening late maturing tobacco that is over-fertilized.

Ethy-gen and Livingston Tobacco Curing Gas are released in the barn during the yellowing stage of the cure. Ethephon is the only approved chemical to use for coloring tobacco in the field. The yellowing obtained from an ethephon application is influenced by weather conditions. Experience has shown that cool, cloudy conditions slow the yellowing rate and coloring may not be uniform. If a producer decides to use ethephon, a few representative test plants should be sprayed and observed for two to four days to determine if desired yellowing can be achieved. If the test plants fail to yellow as desired, further maturing may be needed before the crop should be sprayed. Only *physiologically mature* leaves remaining on the plant after the second or third priming should be treated. Ethrel (2 lbs/gal) was the original ethephon product labeled as a yellowing agent for tobacco and was followed by Prep and Marture XL (6 lbs/gal). Additional generic products have been labeled in recent years. **The use of other chemicals for this purpose is illegal and could result in severe penalty for the grower.**

Growers should follow manufacturer's suggestions on proper use of these materials.

Guidelines for the use of Ethephon (6 lbs/gal. products)*

Application method	Rate pts/A	Spray volume	Application directions
Directed spray	1 1/3	50 to 60 gal/A	Apply with drop nozzles to direct spray to leaves to be harvested. Use coarse spray tips at 35 to 40 psi.
Over-the-top	1 1/3 to 2 2/3	40 to 60 gal/A	Apply as a fine spray using three spray tips over each row to cover all leaves thoroughly. Use a spray pressure of 40 to 60 psi.

*Read and follow all label directions regarding use rates, application procedures, and worker protection standards (WPS). Growers must comply with label requirements regarding worker notification, restricted-entry interval (REI), and personal protective equipment (PPE)

FLUE-CURED TOBACCO DISEASE CONTROL

Charles S. Johnson, Extension Plant Pathologist, Tobacco

Good disease control in flue-cured tobacco results from accurate diagnosis of disease problems, careful consideration of disease severity in each field, and the prudent use of disease control practices. *Consistent disease control depends on the use of several control practices together. Crop rotation, early root and stalk destruction, and resistant varieties should always be used in conjunction with disease-control chemicals*.

ACCURATE DIAGNOSES OF DISEASE PROBLEMS is the first step in controlling flue-cured tobacco diseases. Note any signs of disease during the growing season. Take plant and soil samples for analysis to identify the cause of the problem. Keep a record of what the problem was determined to be, where and when it occurred, and how bad it eventually became, so that you can plan appropriate control practices for the future.

DISEASE-RESISTANT VARIETIES may be the most cost-effective way to control disease. Flue-cured tobacco varieties with resistance to black shank, Granville wilt, and mosaic, as well as cyst and root-knot nematodes, are available to Virginia growers.

CROP ROTATION is particularly effective in helping to control black shank, Granville wilt, most nematodes, and tobacco mosaic. Crop rotation also provides many agronomic benefits. The length of rotation (the longer the better) and the types of alternate crops are among the most important rotation considerations. Table 1 lists some possible rotation crops.

EARLY DESTRUCTION OF ROOTS AND STALKS reduces overwintering populations of nematodes and disease-causing organisms by destroying the tobacco debris that pathogens rely on for food and shelter during the fall and winter. *The earlier and more complete the destruction of tobacco debris, the better the disease control*. The objective of early root and stalk destruction is to pull the roots out of the ground, dry them out, break them up, and get them decayed as soon as possible. Table 2 lists the steps involved.

Table 1. Usefulness of various rotation crops for tobacco disease control[1]

Rotation Crop	Black Shank	Granville Wilt	Nematodes: Root-Knot	Nematodes: Tobacco Cyst	Tobacco Mosaic Virus	Black Root Rot
Fescue	H	H	H	H	H	H
Small grain	H	H	H	H	H	H
Lespedeza 'Rowan'	H	H	H	-	H	L
Soybean	H	H	L[3]	H	H	L
Corn	H	M	L	H	H	H
Sweet potato	H	M	L[4]	-	H	H
Cotton	H	M	N	-	H	L
Milo	H	M	L	H	H	H
Peanuts	H	L	N	H	H	L
Pepper	H	N	N[2]	L	N	H
Potato, irish	H	N	L	L	H	H
Tomato	H	N	N[3]	N	N	M

[1]Adapted from Flue-cured Tobacco Information, North Carolina Cooperative Extension. Ratings indicate the value of each rotation crop for reducing damage caused by each disease in the subsequent tobacco crop, and assume excellent weed control in each rotation crop; H = highly valuable, M = moderately valuable, L = Little value, N = no value – may be worse than continuous tobacco, - = unknown.

[2]May be highly valuable for some species or races of root-knot nematodes

[3]However, root-knot resistant cultivars are highly effective rotation crops for tobacco.

[4]Root-knot resistant sweet potato cultivars are moderately effective rotation crops for tobacco.

Table 2. Steps in early stalk and root destruction

1. Cut stalks into small pieces with a bush-hog or similar equipment *immediately after final harvest if possible*.
2. Plow or disc-out stubble the same day that stalks are cut. Be sure to pull roots completely out of the soil.
3. Redisc the field *2 weeks after the first operation*.
4. Plant a cover crop when root systems are completely dried-out and dead.

Disease Control in Tobacco Greenhouses

Avoid seeding tobacco greenhouses any earlier than necessary. Eliminate any volunteer tobacco plants. Plants closely related to tobacco (tomatoes, peppers, etc.) should not be grown in greenhouses used for transplant production.

Disease-causing organisms can enter a greenhouse in soil or plant debris, so entrances should be covered with asphalt, concrete, gravel, or rock dust. Footwear should be cleaned or disinfected before entering a greenhouse. Float bays should be re-lined with fresh plastic each year and should be free of soil and plant debris.

If tobacco mosaic virus (TMV) may have occurred in the previous year, greenhouse surfaces such as side-curtains, center walkways, and the 2x6 boards that support the float bays should be disinfected. A 1:10 solution of household bleach and water is sufficient for these purposes, as are most disinfectants. There is no need to spray the purline supports or the plastic covers over the greenhouse. Float trays used when TMV may have been present should be washed and cleaned thoroughly before being fumigated. Mosaic has a number of weed hosts (horsenettle, ground cherry) which should be removed from the vicinity of tobacco greenhouses.

Float trays should be cleaned and then fumigated with methyl bromide or aerated steam (140º to 175ºF for 30 minutes) to minimize *Rhizoctonia* damping-off and sore shin. Dry trays should be loosely stacked no more than 5-foot high and completely enclosed in plastic. Use one pound of methyl bromide per 330 cubic feet (400 trays). Trays should be fumigated 24 to 48 hours, then aerated for at least 48 hours before use. Be sure to read the label for space fumigation and follow it exactly.

Don't fill float bays with water from surface water sources like streams or ponds, as water from these sources may be contaminated. Avoid introducing disinfestants into water intended for plant uptake. Moving water from one bay to another can increase spread of water-borne pathogens. Filling bays with water long before floating the trays can make *Pythium* disease problems worse.

Weekly application of 0.5 pound of Dithane DF per 100 gallons of water (1 level tsp/gal) should start approximately one week after seedlings are big enough to cover the tray cells. Spray volume should increase from 3 to 6 gal/1,000 square feet as plants grow. Fungicide application should continue until seedlings are transplanted.

Condensation in the greenhouse favors disease. Temporarily lowering the side-curtains near dusk and ventilating the greenhouse with horizontal airflow fans will help reduce condensation. Minimize overhead watering and the potential for splashing media from one tray cell to another. Correcting drainage problems in and around the greenhouse will also help avoid excess humidity.

To avoid spreading TMV, mower blades and decks should be sanitized with a 1:1 bleach:water solution between greenhouses and after each clipping. Plant debris left on trays after clipping is one of the primary causes of collar rot problems. Use high-vacuum mowers to clip tobacco seedlings. Clippings, unused plants, and used media should be dumped at least 100 yards from the greenhouse.

Bacterial soft rot causes a slimy, watery rot of leaves and stems and can easily be confused with damage from collar rot. Greenhouse management practices that help minimize collar rot will also help prevent bacterial soft rot. Management practices for angular leaf spot and wildfire (two other diseases caused by bacteria) can also help reduce bacterial soft rot as a side-effect.

Specific Diseases Important in Virginia

Diseases like **black shank** and **Granville wilt** are caused by microscopic organisms that live in the soil. Any activity that moves soil from one place to another can spread these diseases. *Crop rotation, early root and stalk destruction, and a resistant variety should all be used before considering the use of a pesticide to control black shank or Granville wilt*.

Table 3. Reactions of flue-cured tobacco varieties to black shank.

	% Survival only[1]		Black Shank Yield Index[2]	
	Race 1	**Race 0**	**Race 1**	**Race 0**
Varieties with the *Ph* gene:				
SP 225	78	97	74	92
SP 168	54	99	55	101
SP 227	55	99	55	99
NC 810	51	85	52	87
SP NF3	54	63	51	59
SP 220	52	99	51	98
NC 471	55	99	50	89
NC 196	44	97	48	107
SP 234	46	*nt*[3]	47	*nt*
SP H20	43	98	40	93
PVH 1118	36	*nt*	37	*nt*
NC 291	32	99	34	106
NC 71	31	97	33	101
RG H51	31	92	32	96
CC 27	26	100	30	114
NC 297	29	95	30	98
NC 299	25	97	26	104
NC 72	24	97	26	106
CC 37	23	*nt*	25	*nt*
NC 102	16	96	16	103
Varieties without the *Ph* gene:				
K 346	61	79	60	78
NC 606	44	64	41	61
SP 210	41	75	39	72
K 149	41	57	39	54
CC 13	23	*nt*	38	*nt*
K 326	24	44	26	47

[1]Average % survival calculated from % disease near 2nd harvest in 10 field experiments, 2004-2007, under heavy black shank disease pressure without a soil fungicide; 0 = worst, 100 = best.

[2]Black Shank Yield Index = relative yield index from 2006 and 2007 Virginia OVT tests adjusted for % survival in black shank resistance tests, 2004-2007. A value of 100 reflects the average yield among varieties in the OVT experiments at 100% stand.

[3]*nt* = "not tested"; no data available from land-grant university tests in tobacco states.

Table 4. Reactions of flue-cured tobacco varieties to Granville wilt.

Varieties:	% Survival only[1]	Granville Wilt Yield Index[2]
SP 227	92	92
NC 810	87	88
SP 220	88	87
K 346	86	86
CC 37	78	86
SP 225	90	86
CC 27	75	85
NC 299	79	85
SP 168	81	83
SP 234	81	82
NC 72	73	81
CC 13	76	81
K 149	84	80
SP 210	82	78
NC 196	71	78
SP H20	78	74
SP NF3	79	74
NC 297	72	74
NC 102	68	73
NC 606	76	72
NC 471	80	72
K 358	72	69
NC 71	67	69
NC 291	63	67
RG H51	62	65
PVH 1118	62	64
K 326	57	61

[1]Average % survival calculated from % disease near 2nd harvest in 10 field experiments in North and South Carolina, 2004-2007, under heavy disease pressure without soil fumigation; 0 = worst, 100 = best.

[2]Granville Wilt Yield Index = relative yield index from 2006 and 2007 Virginia OVT tests adjusted for % survival in Granville wilt resistance tests, 2004-2007. A value of 100 reflects the average yield among varieties in the OVT experiments at 100% stand.

Table 5. Granville-wilt resistance ratings and on-farm test results for selected flue-cured tobacco cultivars.

Variety	2008 Granville Wilt Yield Index[1]	% Survival at End of Season (6-7 September)[2] 2005 10.5 gpa Telone C17	2005 Untreated Soil	2006 Untreated Soil
NC 810	88	71	62	nt
Speight 220	87	75	53	nt
K 346	86	nt	nt	78
CC 27	85	nt	nt	75
Speight 168	83	68	63	73
Speight 234	82	nt	nt	72
K 149	80	54	40	nt
Speight H20	74	37	30	nt
NC 471	72	nt	nt	81
NC 606	72	64	37	62
NC 71	69	39	32	35
NC 291	67	nt	nt	25
PVH 1118	**64**	**nt**	**nt**	**36**

[1]Granville Wilt Yield Index = relative yield index from 2006 and 2007 Virginia OVT tests adjusted for % survival in Granville wilt resistance tests, 2004-2007. A value of 100 reflects the average yield among varieties in the OVT experiments at 100% stand.

[2]nt = not tested. Test results from on-farm trials in Brunswick County, Virginia.

Black shank is caused by a fungus-like pathogen that lives in soil and attacks tobacco roots and stalks. Table 3 presents black-shank resistance ratings for flue-cured tobacco varieties. *Virginia tobacco producers who have used varieties possessing the Ph gene should assume their fields contain race 1 of the black shank pathogen*. Growers planting black-shank problem fields in 2008 should seriously consider preventative soil fungicide use in addition to planting the highest black-shank resistance available. Remember that while soil fumigants provide good to excellent control of Granville wilt and nematodes, they are generally not effective for black-shank control.

Granville (Bacterial) Wilt is caused by a soil-inhabiting bacterium that invades tobacco plants through roots and often kills the entire plant. The pathogen can also invade tobacco plants through wounds, so early and shallow cultivation and topping by hand can help reduce the spread in infested fields. Although symptoms are somewhat similar to those for black shank, intermediate symptoms of Granville wilt involve wilting on only one side, and wilted leaves may retain their normal green color rather than yellowing. *Crop rotation and the use of resistant varieties are ESSENTIAL for Granville wilt control*. Including soybeans as a rotation crop has proven particularly beneficial in reducing losses to this disease (Table 1). Disease reduction and yield increases are generally much larger from use of resistant varieties compared to soil fumigation (Tables 4 and 5).

Tomato spotted wilt virus (TSWV) is spread by various species of thrips, usually within the first few weeks after transplanting. Greenhouse application of an appropriate systemic insecticide can significantly reduce damage caused by TSWV.

Tobacco mosaic virus (TMV) can be spread by contaminated clipping mowers in the greenhouse, from tobacco roots and stalks remaining in soil from previous crops, from weed hosts such as horsenettle and ground cherry, from contaminated objects and surfaces (trays, sheets, etc.), and from manufactured tobacco products. Workers should wash their hands regularly during planting. Rogueing infected plants before layby will reduce virus spread within a field. However, tobacco mosaic can't be eliminated from infested fields without crop rotation and early destruction of roots and stalks. Mosaic resistant varieties can reduce damage and may help eliminate residual virus in infested fields. *Varieties such as CC 27, CC 37, NC 102, NC 297, NC 471, and Speight H20 may be appropriate for fields with a history of 30 to 50 percent of the plants infected with mosaic before topping*. If a TMV-resistant variety is planted, the entire field should be planted to the resistant variety.

Blue mold and target spot can be significant problems for Virginia tobacco producers. The fungicide Quadris is registered for target spot control, but target spot often occurs early in the harvest period, and timely harvest of leaf at lower stalk positions often reduces disease to insignificant levels.

Tobacco Cyst (TCN), Root-knot, and Lesion Nematodes are microscopic worms that live in the soil and feed on tobacco roots. *Significant nematode* *problems are usually found in fields continuously planted with tobacco*. The southern root-knot nematode (*Meloidogyne incognita*) is the most common species of root-knot nematode in Virginia, but other types of root-knot can also be present in damaging numbers. Most flue-cured tobacco varieties currently grown are resistant to the southern root-knot nematodes, with the exception of Coke 371-Gold. Root galling on other tobacco varieties indicates the presence other species or races of root-knot nematode. Rotation intervals should be increased as long as possible and nematicides should be used when galling has been observed on root-knot resistant varieties. Flue-cured tobacco varieties CC 13 and CC 37 claim some resistance against these other species of root-knot. Rotating tobacco with grasses or small grains reduces populations of tobacco cyst and root-knot nematodes, but take care to plant nematode resistant cultivars of some rotation crops (Table 1). Forage legumes are often good hosts for root-knot nematodes. Lesion nematode populations often may not be as reduced by crop rotation as are tobacco cyst or root-knot nematodes. However, a single year of forage or grain pearl millet can cause a reduction in lesion nematode numbers similar to that of soil fumigation. Nematicide use may be profitable when a soil assay detects 50 to 100 lesion nematodes/500cc of soil. Preplant nematicide use may be necessary when root-knot nematode populations are high, as indicated in the table below.

Varieties with the Ph gene reduce TCN populations dramatically, although a recommended nematicide will be necessary to produce acceptable yield and quality when TCN populations are high (Table 3).

Nematicides should always be used in conjunction with resistance, rotation, and early root and stalk destruction. Poor control of nematodes and soil insects can increase disease losses in fields infested with black shank and Granville wilt.

Application Methods

The performance and safety of a chemical is dependent on the use of proper application methods. Improper pesticide use can reduce yields as severely as any pest and will not provide satisfactory disease control. Proper pesticide use depends upon correct diagnosis of the problem, a clear understanding of the label for each chemical being applied, proper calibration of application equipment, and strict adherence to label directions and all federal, state, and local pesticide laws and regulations.

Preplant Incorporated (Preplant) – Refer to section under weed control.

Foliar Spray (FS) – Greenhouse applications should not begin until seedlings are at least the size of a dime, but should be repeated at five- to seven-day intervals up to transplanting. Use flat-fan, extended range tips at approximately 40 psi to maximize results. **Field sprays** for leaf diseases should generally be performed using hollow-cone tips to apply a fine spray of 20 to 100 gal/A to maximize coverage as plants increase in size. Spray pressures should generally range between 40 to 100 psi. Both the tops and bottoms of leaves need to be covered. The use of drop nozzles will significantly improve disease control after layby by improving spray coverage on bottom leaves where foliar diseases are usually concentrated.

Fumigation – F-Row: Inject fumigant 6 to 8 inches deep with one chisel-type applicator in the center of the row. Soil should be sealed in the same operation by bedding the fumigated row area with enough soil to

Interpreting root-knot infestation levels

Risk of Crop Loss	% Roots Galled	Nematodes/500 cc of soil: Fall Sample	Nematodes/500 cc of soil: Spring Sample	Control Options
Very Low	1 to 10	1 to 200	1 to 20	Practice crop rotation and/or plant a resistant variety.
Low	11 to 25	201 to 1,000	21 to 100	Use crop rotation in combination with a resistant variety and/or a nematicide.
Moderate	26 to 50	1,001 to 3,000	101 to 300	Increase rotation interval. Also use a resistant variety and a nematicide rated 'G' or higher.
High	Over 50	Over 3,000	Over 300	Increase rotation interval if at all possible. Use a resistant variety with a nematicide rated 'E'.

bring the soil surface 14 to 16 inches above the point of injection. **F-Broadcast**: Space chisels 8 inches apart and inject fumigant 10 to 12 inches below the soil surface. Soil should be sealed immediately with a roller, drag, or similar piece of equipment.

After fumigation, leave soil undisturbed for an "exposure period" of seven to 14 days. Cold, wet soil slows the diffusion of fumigants, so wait longer before working soil under such conditions. Transplants will be injured if the fumigant is still present at transplanting, so soil should be aerated after the exposure period. Planting should be safe when the fumigant can no longer be smelled in the soil root zone. This condition is usually reached (depending upon temperature and moisture) within three weeks after fumigations. To hasten aeration (especially after cold, wet weather): 1) **Row** – use a chisel in the bed without turning the soil; 2) **Broadcast** – plow or cultivate above the depth of the treatment zone; **Caution**: avoid contaminating fumigated soil with untreated soil.

Band-row (B-row) – Refer to nematicide table for instructions for the application of granular formulations of pesticides.

Precautionary and Restriction Statements – Read and follow all directions, cautions, precautions, restrictions, and special precautions on each product label. Take labels seriously. This publication must not be used as the only source of precautionary and restriction statements.

Table 6. Diseases of tobacco seedlings

Disease	Material	Rate
Angular Leaf Spot or **Wildfire** (Pseudomonas)	Agrimycin 17, Streptrol, etc	100-200 ppm (2-4 tsp/3gal)
Remarks: Foliar Spray: 100 ppm = 4 oz/50 gal or ½ lb/100 gal 200 ppm = ½ lb/50 gal or 1 lb/ 100 gal		
Anthracnose (Colletotrichum gloeosporoides) **Blue Mold** (Peronospora tabacina) **Target Spot** (Thanatephorus cucumeris)	Dithane DF Rainshield	0.5 lb/100 gal (1 level tsp/gal)
Remarks: Apply as a fine foliar spray to the point of run-off to ensure thorough coverage. Begin applications before disease has been observed, but not before seedlings are the size of a dime. Use 3 gal of spray mixture/1000 sq. ft. when plants are about the size of a dime. Use 6-12 gal/1000 sq. ft. when the canopy has closed and plants are close to ready for transplanting. Repeat applications on a 5- to 7-day interval to protect new growth.		
Blue mold (Peronospora tabacina)	Aliette	0.5 lb/50 gal
Remarks: Foliar spray; apply no more than 0.6 lb/1,000 sq.ft; CAN BURN PLANTS IF WASHED INTO MEDIA OR FLOAT WATER; no more than 2 sprays/greenhouse season.		
Pythium Root Rot (Pythium spp.)	Terramaster 35WP	2 oz/100 gal of float bed water
	Terramaster 4EC	**Preventative:** 1 fl oz/100 gal **Sequential:** 0.9 fl oz/100 gal **Curative:** 1.4 fl oz/100 gal **2nd Curative:** 1-1.4 fl oz/100 gal.
Remarks: Can be used before or after symptoms appear, but no earlier than 2 weeks after seeding. If symptoms reappear, a second application can be made no later than 8 weeks after seeding. No more than 2.8 fl.oz./100 gallons of water may be applied to any crop of transplants, regardless of the number of applications. MUST BE EVENLY DISTRIBUTED. When mixing, first form dilute emulsion, then distribute diluted emulsion evenly and thoroughly in float-bed water.		
Tomato Spotted Wilt Virus (TSWV)	Actigard 50WG	1-2 oz/100,000 plants (~350- 288-cell trays)
Remarks: *Must submit liability waiver to receive a copy of the label, which is required for use.* **One** foliar application in the greenhouse 5-7 days prior to transplanting in sufficient water to ensure good coverage (~6 gal/1,000 sq. ft.); **use of accurate rate is *critical* to avoid crop injury. In general**, a 10%-15% stand loss due to TSWV should be expected before considering application of Actigard to tobacco seedlings. Use of systemic insecticides such as imidacloprid or thiamethoxam as well as Actigard will significantly improve control of TSWV. Tank mixtures are not recommended, but product may be left on foliage or washed off into the root ball.		

Field Diseases of Tobacco

Root and stem diseases

Product	Rate/A	Application Method[1]	Disease[2]		
			Black Shank	Black Root Rot	Granville Wilt
Ridomil Gold EC or SL	1-2 pt	Preplant	F	—	—
Ultra Flourish	1-2 qt	Preplant	F	—	—
Ridomil Gold EC	1.0 pt + 1.0 pt	Preplant + layby	VG	—	—
Ultra Flourish	2 qt + 2 qt	Preplant + layby	VG	—	—
Ridomil Gold EC or SL	1.0 pt + 1.0 pt	1st cultivation + layby	VG	—	—
Ultra Flourish	2 qt + 2 qt	1st cultivation + layby	VG	—	—
Ridomil Gold EC or SL	1 pt + 1.0 pt + 1.0 pt	Preplant + 1st cultivation + layby	VG	—	—
Ultra Flourish	1 qt + 2 qt + 2 qt	Preplant + 1st cultivation + layby	VG	—	—
Telone C 17	10.5 gal	F-Row	P-F[3]	F	G
Chlor-O-Pic	3 gal	F-Row	P-F	F	G
Chloropicrin 100	3 gal	F-Row	P-F	F	G
Pic Plus	4 gal	F-Row	P-F	F	G

[1]**Preplant** – broadcast, preplant incorporated spray; 1st cultivation – broadcast spray just before 1st cultivation ; **layby** - broadcast spray just before layby; **F-Row** – inject 8 inches deep in row with single shank in center of row. Do not use more than a total of 3 qt of Ultra Flourish or 3 pt of Ridomil Gold per acre.

[2] Control rating - F=fair; G=good; VG=very good. (-) - No disease control or not labeled for this disease.

[3]Fumigants will not control black shank without use of a soil fumigants, but may improve control from a single fungicide application versus two.

Foliar diseases

Disease	Material	Rate[1]	Application Method[2]
Blue mold *(Peronospora tabacina)*; **Tomato Spotted Wilt Virus** (TSWV)	Actigard 50WP	0.5 oz/20 gal/A	Foliar
Remarks: Begin applications when blue mold disease threatens and plants are 12 inches tall. Up to 3 sprays may be applied on a 10-day schedule. Treated plants require 3-5 days to fully respond to each application. TSWV sprays beginning within 7 days of transplanting or whenever plants have recovered from transplant shock may also be used to follow-up on greenhouse application of Actigard for TSWV control.			
Blue mold *(Peronospora tabacina)*	Aliette	2.5-4.0 lb/A	Foliar
Remarks: No more than 5 sprays allowed, 3 day pre-harvest interval; don't tankmix.			
Blue mold *(Peronospora tabacina)*	Ridomil Gold EC	0.5-1 pt + 0.5 pt/A	Preplant + Layby
	Ultra Flourish	1-2 pt + 1 pt/A	
Remarks: Strains of the blue mold pathogen are often insensitive to mefenoxam, but mefenoxam may control sensitive strains early in the season, as well as Pythium damping-off. Read precautionary and rotation crop restrictions.			
Blue mold *(Peronospora tabacina)*	Acrobat MZ	2.5 lbs/100 gal of water	Foliar Spray
	Acrobat 50WP + Dithane DF Rainshield	7.0 oz/100 gal water + 2.0 lb/100 gal water	
	Forum + Dithane DF Rainshield	7.0 oz/100 gal water + 2.0 lb/100 gal water	
Remarks: Begin sprays when the Blue Mold Advisory predicts conditions favorable for disease. Continue applications on a 5- to 7-day interval until the threat of disease subsides. Apply 20 to 30 gal/A of spray solution during the first several weeks after transplanting and gradually increase spray volume as the crop grows. Spray volumes should reach 40 gal/A by layby and should range between 80 and 100 gal/A on tobacco ready to be topped. Do not exceed 2.5 lb/A of Acrobat per application or 10 lb/A per season. Do not apply after the early button stage or within 21 days of the first harvest.			
Blue mold *(Peronospora tabacina)*; **Frogeye** (Cercospora nicotianae); **Target Spot** (Thanatephorus cucumeris)	Quadris	6-12 fl. oz.	Foliar Spray
Remarks: First application for blue mold should be made at first indication of disease in the area; for target spot, spray at or soon after layby; don't spray Quadris "back-to-back" for blue mold, but alternate with another fungicide; spray sufficient water volume for complete coverage and canopy penetration; may enhance weather flecking, but this shouldn't affect yield or quality; up to 4 applications/year allowed; may be applied up to the day of harvest; tank mixing with insecticides formulated as ECs or containing high amounts of solvents may cause some crop injury.			

[1]Use higher rates of protectant fungicides for mature plants.

[2]**Foliar spray** - apply at 40-100 psi in 20 to 100 gal of water. The amount of water depends on size of plant. Use hollow-cone nozzles (TX12, etc.) Use drop nozzles to apply fungicide to both the top and bottom leaves. **Preplant + layby** - first application preplant followed by a second spray just before last cultivation.

Tobacco nematodes

Product	Rate/A, Application Method[2]	Nematodes [1]	
		Root-Knot and Others	Tobacco Cyst
Fumigants			
Chlor-O-Pic	3- 4 gal, Row	E	G
Metam CLR	25 gal, Row	—	G
Pic Plus	4.2 gal, Row	E	G
Telone II	9-10 gal, Row	E	G
Telone C-17	10.5 gal, Row	E	G
Granular or Liquid Non-Fumigants			
Nemacur 3SC[3]	1.3-2 gal, PPI	G	—
Temik 15G	20 lbs, Band	G	G

[1]Control ratings: E=Excellent; G=Good; F=Fair; P=Poor; (—)=no control or not labeled. Use higher rates for higher nematode populations or for heavier soils.

[2]**PPI**=Sprayed broadcast, preplant incorporated; **Row**=inject 8 inches deep in row with single shank - 21-day waiting period before planting; **Band**= apply granules in a 14-inch band, then incorporate. Granules should be covered with 2-6 inches of soil when forming beds. **Do not** apply Temik more than one week before transplanting. Be aware that adequate soil moisture is required before the product is activated.

[3]Alternate use of Nemacur with other nematicides. Nemacur will not be commercially available after 2007.

Diseases of Tobacco

There Are No Chemical Controls For the Following Diseases

Disease	Remarks
Botrytis Blight (*Botrytis cinerea*)	This disease is restricted to tobacco greenhouses. A wet rot is often first observed on stems or leaves. A gray, downy material may be present on the surface of diseased areas. Reducing surface moisture on leaves and stems by correct watering and improved ventilation, and collecting and removing loose leaf material from clipping will help reduce damage.
Brown Spot (*Alternaria alternata*)	Can be severe on mature tobacco, especially during periods of high humidity. Avoid leaving mature leaves in the field. Good sucker control also helps reduce disease incidence.
Collar Rot (*Sclerotinia sclerotiorum*)	Symptoms resemble damping-off. Small groups of plants have brown, wet lesions near the base of stems. Leaf rot may appear to progress from leaf margins or tips toward the stem. White, cottony mold may be visible. Irregularly shaped white to black objects (sclerotia) may also be found attached to severely infected plant parts. Infected plants, as well as plants immediately adjacent to diseased areas, should be discarded as soon as possible. Improving ventilation and reducing excess moisture may help reduce spread. Proper clipping procedures may also help.
Frenching (nonpathogenic causal agent)	This disorder has been associated with toxins produced by a nonpathogenic bacterium, *Bacillus cereus*, and other nonpathogenic microorganisms. Frenching is more prevalent on wet, poorly aerated soils. This problem can be more severe on neutral or alkaline soils and is sometimes associated with lack of available nitrogen or other minerals. Proper drainage and fertilization can be beneficial. Do not plant in alkaline soils and avoid heavy applications of lime.
Weather Fleck (ozone)	This disorder appears as small brown to tan leaf spots in the plant bed and field. The major cause of this problem is ozone from car, industrial, and natural sources. Hot humid days followed by heavy rains increase severity of problem.

WEED CONTROL IN FLUE-CURED TOBACCO

Charles S. Johnson, Extension Plant Pathologist, Tobacco

Good weed control uses crop rotation, early root and stalk destruction, cultivation, and appropriate use of herbicides. Application of a herbicide before transplanting (PPI) or over-the-top at transplanting (OT) will reduce reliance on the first cultivation for early-season weed control. The number of cultivations can often be reduced when a herbicide has been applied PPI or at transplanting. Some herbicides may also be applied to the row middle just after the last cultivation to obtain full-season weed control. Herbicide use should be based upon the specific weeds present in each field, the weed-control program that integrates best with overall farm management practices, herbicide cost in relation to performance and crop safety, and anticipated rotational crops. Herbicide performance and safety depend upon the use of correct application methods. Special effort should be made to apply all herbicides exactly as stated on the product label.

Important Considerations in Herbicide Use

Selecting the Proper Herbicide

Weed Identification – Identifying the problem weeds in each field should be the first step in any weed control program. Use of herbicides with rotation crops may reduce populations of hard-to-control weeds in tobacco fields and avoid some of the problems associated with use of tobacco herbicides. The table on page 39 is a relative summary of herbicide performance for the majority of weeds found in flue-cured tobacco fields in Virginia.

Soil Texture and Organic-Matter Content – Herbicide rates should increase as percent organic matter increases and as soil texture changes from coarse to fine. However, the lowest recommended rate should always be used when percent organic matter is less than 1 percent, regardless of soil texture. The soil textures listed in herbicide labels and recommendations are as follows: **Coarse Soils** - sands, loamy sands, and sandy loams; **Medium Soils** - sandy clay loams, loams, silt loams, and silts; **Fine Soils** - clay loams, silty clay loams, and clays. The percent organic matter of your soils can be determined by taking a soil sample and submitting it to a soils laboratory for analysis.

Proper Herbicide Application

Soil Preparation – Most herbicides used in tobacco fields control weeds by preventing seed germination. Already established weeds are not significantly affected. All weed growth and crop stubble should be thoroughly worked into the soil prior to the application of most tobacco herbicides. The soil should be moist and loose, with all clods broken up, before a herbicide is applied.

Spray Equipment – A standard low-pressure (25 to 50 psi) boom sprayer should be used to apply herbicides with liquid or wettable powder formulations. Use in 20 to 40 gallons of water per acre. Check for clogged nozzles and screens frequently while spraying. Use 50-mesh screens in strainers, nozzles, and suction units. Clean or replace dirty or worn out sprayer, boom, and nozzle parts to ensure uniform application. Be sure to calibrate the sprayer before use to avoid crop injury and/or poor herbicide performance from improper spray volume or a non-uniform spray pattern. Ensure that the spray solution is continuously agitated. Do not apply a herbicide in strong wind, since wind can cause uneven coverage. Poast must be applied at higher pressures (40 to 60 psi) using smaller spray volumes (5 to 20 gallons of water per acre). Use only hollow-cone or flat-fan nozzles to apply Poast. Never leave a spray mixture in a sprayer overnight!

Herbicide Incorporation – Herbicides should generally be incorporated as soon after application as possible. Use a field cultivator or a combination, tandem, double disc, or disc harrow set to cut 4 to 6 inches deep. Avoid using a large field disc to incorporate PPI herbicides. Discs should be no more than 24 inches in diameter and 8 inches apart. Shallow incorporation with implements set to cut less than 2 inches deep can result in erratic weed control. **A single cultivation does not adequately incorporate herbicides, and may increase crop injury and decrease weed control.** Incorporating equipment should be operated in two different directions, at right angles to each other, at 4 to 6 mph. PTO-driven equipment (tillers, cultivators, hoes) perform best on coarse soil types. PTO-driven equipment should be set to cut 3 to 4 inches deep and should not be operated at a speed greater than 4 mph. Tillage is often required with over-the-top herbicide use. Irrigation is also often required to incorporate tobacco herbicides applied at layby. Using incorporation equipment and/or tractor speeds not listed on the product label may result in poor or erratic weed control and/or crop injury.

Undesired Effects of Herbicide Use

Effect of Preplant Applications on Early-Season Tobacco Growth – Herbicides applied before transplanting sometimes inhibit the root development of transplants, delaying plant growth during the first month after transplanting. Full-season weed control can be obtained, and possible early-season growth reductions avoided, by applying herbicides at transplanting and layby.

Effects of Herbicides on Rotation Crops – Residues from some tobacco herbicides may reduce the growth of crops following tobacco. These effects are discussed in the labels for the particular herbicides involved. Potential carry-over can be reduced by: 1) using the minimum labeled rates for the chemical, for your weed problems, on your soils; 2) applying herbicides in a band at transplanting and/or layby rather than broadcast PPI; 3) fall tillage for early root and stalk destruction; and, 4) by deep plowing before seeding the small-grain crop.

Flue-cured Tobacco Herbicides

Preplant Incorporated Herbicides (PPI) Apply the herbicide in an even broadcast application. Avoid spray overlap! Use fan-type, flood-jet, or raindrop nozzles. Incorporate the herbicide immediately after application using recommended equipment.

Over-the-Top after Transplanting (OT) and Layby Herbicides An OT application can be made as either a band or broadcast application within seven days of transplanting. Tillage is required immediately before or at the time of an OT application if the OT application is made more than two days after transplanting, or if rain has fallen or irrigation was applied since the crop was transplanted.

1. **Band Application** – Apply the herbicide in a 14- to 24-inch band over the row using fan-type, even-spray nozzles (8004E, etc.). The amount of herbicide per acre of crop is reduced with band application and can be determined by the formula below.

2. **Broadcast Application** - Apply the herbicide in an even broadcast application using a sprayer equipped with fan-type nozzles (8004, etc.).

Apply **layby herbicides** as directed sprays to row middles immediately after the last normal cultivation. Use drops equipped with flat, flood-jet (TK2, TK4, etc.) or even, flat-fan (8004, etc.) nozzles to apply the herbicide solution in a 16- to 30-inch band in the row middles. Use nozzles that apply one-half (1/2) the normal number of gallons per acre where spray nozzles on the end of the boom pass over the same row middle twice (to prevent over-application). Use the formula above to determine the amount of product to use for a band application. Irrigation will be required if 1 to 2 inches of rain do not fall within seven to ten days after application (to ensure herbicide activation).

Precautionary and Restriction Statements

Read and follow all directions, cautions, precautions, and restrictions on each product label. Take labels seriously. This publication must not be used as the sole source of precautionary and restriction statements.

Band Application Formula

$$\frac{\text{Lbs of}}{\text{Product/Acre}} = \frac{\text{Band Width (inches)}}{\text{Row Spacing (inches) per/A}} \times \text{Broadcast Rate}$$

Relative effectiveness of herbicides for tobacco*

Grasses and Nutsedge

Herbicide	Barnyard-grass	Bermuda-grass	Broadleaf Signalgrass	Crab-grass	Crowfoot grass	Fall Panicum	Fox- tails	Goosegrass	Johnsongrass (seedling)	Texas Panicum	Nutsedge
Command	E	P-F	E	E	E	E	E	E	G	G	P
Devrinol	G	P	F	E	E	G	E	E	F	-	N
Poast	F-G	G	E	G	F	E	E	G	E	E	N
Prowl or Pendimax	G	P	G	E	E	G	E	E	G	G	N
Spartan	F	P	P	F	F	F	F	F	F	F	E
Tillam	G	P	P	E	E	G	E	G	G	P	G

Broadleaf Weeds

Herbicide	Carpet-weed	Cocklebur	Galinsoga	Jimsonweed	Lambsquarters	Morning-glory	Pig- weed	Purslane	Prickly sida	Rag- weed	Sickle-pod	Smart- weed
Command	P	F	P-F	G	G	P	P	G	E	F-G	P	G
Devrinol	G	F	P-F	P	G	P	G	G	P	F	P	P
Poast	N	N	N	N	N	N	N	N	N	N	N	N
Prowl or Pendimax	G	P	P	P	G	P	G	G	P	P	P	P
Spartan	G	F-G	F	F-G	G	G	G	G	P	P	--	G
Tillam	G	P	P	P	G	P	G	G	P	P	P	P

*E = 90 to 100% control; G = 76 to 90%; F = 50 to 75%; P = 20 to 50%; N = Less than 20%; - = no data. This table gives general ratings of relative herbicidal activity. Activity varies with weather conditions, soil type and application method. Under non-optimal conditions, activity may be less than indicated.

Weed control in flue-cured tobacco fields

Weed Problems	Soil[1] Texture	Chemical Lbs Active Ingredient/A	Product per Acre	Application[2] Method
Pigweed, lambsquarters, nightshade, purslane, smartweed, velvetleaf, spurred anoda, carpetweed, cocklebur, cotton, groundcherry, morningglory, common ragweed		Carfentrazone 0.012-0.024 0.013-0.023	 Aim 0.5-1.0 oz. Aim EC or Aim EW 0.8-1.5 fl. oz.	Pretransplant burndown; shielded or hooded spray before layby; directed spray after 1st harvest
Remarks: Spray solution will cause extensive burn to broadleaf plants (and tobacco leaves) on contact. Pretransplant interval = 1 day; preharvest interval = 6 days. Do not apply more than 2.0 oz. Aim or 3.0 fl oz. Aim EC or EW per acre per season.				
Barnyardgrass, broadleaf signalgrass, crabgrass, field sandbur (suppression), foxtails, seedling Johnsongrass, fall panicum, velvetleaf, jimsonweed, lambsquarter, prickly sida, purslane, spurred anoda, venice mallow, common ragweed, smartweed, cocklebur (suppression), shattercane	 Coarse Fine	Clomazone 0.75 1.0	Command 3ME 2.0 pt 2.7 pt	OT
Remarks: Use the higher rate for heavy weed pressure or heavy soils. Transplants should be placed below the treated area. Do not use in plant beds.				
Barnyardgrass, carpetweed, crabgrass, fall panicum, foxtails, goosegrass, johnsongrass from seed, lambsquarters, pigweed, common purslane, ragweed (suppression), ryegrass; check label for uncommon weeds.	 Coarse Medium Fine Coarse Medium Fine	napropamide 1.0 1.0-1.5 2.0 1.0 1.0-1.5 2.0	Devrinol DF 2.0 lb 2.0-3.0 lb 4.0 lb Devrinol 2E 2 qt 2-3 qt 4 qt	PPI, OT, Layby PPI only
Remarks: For PPI application, incorporate the same day as applied. Small grain injury may result from PPI application method.				
Grass weeds and volunteer small grain	All types Single use: Sequential use:	sethoxydim 0.28 0.19	Poast 1.5 pt + 2 pt oil concentrate 1 pt + 2 pt oil concentrate	Postemergence
Remarks: Apply to actively growing grasses at 40-60 psi in 5-20 gal/A through hollow-cone or flat-fan nozzles. May be banded or applied broadcast. Do not apply more than 4 pt/A per season or within 42 days of harvest.				

Weed control in flue-cured tobacco fields (cont.)

Weed Problems	Soil[1] Texture	Chemical Lbs Active Ingredient/A	Product per Acre	Application[2] Method
Annual spurge, barnyardgrass, carpetweed, crabgrass, crowfoot grass, Florida pusley, foxtails,		pendimethalin	Prowl 3.3 EC or Pendimax 3.3	
goosegrass, johnsongrass from seed,	Coarse	0.74-0.99	1.8 – 2.4pt	PPI only
lambsquarters, panicums, pigweed,	Medium	0.74-1.24	1.8 - 3.0 pt	
purslane, signalgrass.	Fine	0.99-1.24	2.4 - 3.0 pt	
	Coarse	0.50 – 0.74	1.2 – 1.8 pt	Layby only
	Medium	0.74 – 0.99	1.8 – 2.4 pt	
	Fine	0.74 – 0.99	1.8 – 2.4 pt	
			Prowl H_20	
	Coarse	0.95	2.0 pt	PPI only
	Medium	0.95 – 1.19	2.0 – 2.5 pt	
	Fine	1.19	2.5 pt	
	Coarse	0.71	1.5 pt	Layby only
	Medium	0.95	2.0 pt	
	Fine	0.95	2.0 pt	

Remarks: For silt and silt loam soils, use 2.4-3.0 pt/A of Prowl 3.3EC or 2.5 pt/A of Prowl H_2O for PPI applications. *Rates are for broadcast application and must be adjusted for banded sprays based on the width of the intended spray band and soil texture.* Applied according to directions and under normal growing conditions, Prowl should not harm transplanted tobacco, but can temporarily retard growth under stressful conditions (cold/wet ot hot/dry weather). Layby applications should be made as a directed spray in a 16- to 24-inch band centered between rows. Spray contacting tobacco leaves may cause deformations. Crop injury may result if winter wheat and winter barley are no-till planted in the fall after spring application of Prowl. Don't feed forage or graze livestock for 75 days after planting wheat or barley in Prowl-treated land.

Weed Problems	Soil[1] Texture	Chemical Lbs Active Ingredient/A	Product per Acre	Application[2] Method
Groundcherry, hairy galinsoga,		sulfentrazone	Spartan 75DF	After bedding,
jimsonweed, lambsquarters,	Coarse	0.25	5.3 oz	before
morningglory (except pitted),	Medium	0.31	6.7 oz	transplanting
nutsedge, pigweed, prickly sida,	Fine	0.38	8.0 oz	After bedding,
Pennsylvania smartweed. Suppresses	Coarse	0.25	Spartan 4F	before
most grasses, foxtail, panicums,	Medium	0.31	8 fl oz (0.50 pt)	transplanting
cocklebur, signalgrass, spurges. Check	Fine	0.38	10 fl oz (0.62 pt)	
label for uncommon weeds.			12 fl oz (0.75 pt)	

Remarks: Apply this product only as specified on the label. Do not apply to soils classified as sands with less than 1% organic matter and shallow groundwater. *Most tobacco fields in Virginia contain coarse to medium textured soils.* Do not impregnate on fertilizer. Apply to soil surface after field has been prepared for planting. Apply within 14 days of transplanting, **after** beds are knocked down for planting. **Do not** apply at or after transplanting. Do not disturb treated soil below a 2 inch depth. *Crop injury can occur when incorporation is poor, transplants are set too shallow, or heavy rain falls near transplanting.* **Do not** apply Spartan more than once per season. Do not seed small grains within 4 months of application. Do not plant cotton or canola within 18 months of use.

Weed control in flue-cured tobacco fields (cont.)

Weed Problems	Soil[1] Texture	Chemical Lbs Active Ingredient/A	Product per Acre	Application[2] Method
Barnyardgrass, bermudagrass, crabgrass, crowfoot grass, Florida pusley, foxtails, goosegrass, ground cherry, lambsquarters, henbit, pigweed, purslane, purple and yellow nutsedge, check label for uncommon weeds	All types	pebulate 4.0	Tillam 6E 2.6 qt	PPI
Remarks: Incorporate immediately after application.				

[1]When the soil has less than 1% organic matter, use the rate for the coarse soil texture recommendations. **Coarse** - sands, loamy sands, sandy loams; **Medium** - sandy clay loams, silts; **Fine** - clay loams, silty clay loams, clays.

[2]PPI = Preplant incorporated. Delay in growth may result under adverse conditions and/or when poor application practices have been used. OT = Over-the-top after transplanting as a band or broadcast application. Layby = Application of herbicide in row middle after last cultivation. Preplant burndown = broadcast spray before transplanting in conservation tillage production system. Shielded or hooded spray = application to row middles only using sprayer with shields or hoods to prevent spray contact to tobacco leaves. Directed spray = spray directed toward row middles and surface of row beds after sequential harvesting has removed sufficient leaves that spray will not contact remaining crop leaves.

INSECTS ON TOBACCO

Paul J. Semtner, Extension Entomologist

Management of Tobacco Insects

Several species of insects pose serious threats to tobacco in the field, the greenhouse, and the curing barn. Insects damage the roots, destroy the leaves and buds, reduce leaf quality, and transmit several important tobacco diseases.

Integrated pest management (IPM) combines cultural, natural, and chemical controls to maintain insect pest populations below levels that cause economic damage to the crop. IPM promotes using insecticides only when they are needed. A certain amount of insect damage does not reduce crop value enough to pay for the cost of treatment. In addition, tobacco plants often compensate for insect damage. IPM helps to reduce pesticide residue levels, environmental contamination, and human exposure to pesticides; maximizes profits; and optimizes natural control provided by beneficial organisms.

Cultural controls

Several cultural practices help reduce insect infestations and decrease the need for insecticide applications. The following cultural practices aid in the management of insect pests on tobacco.

1. **Plow early in the spring** at least four weeks before transplanting to reduce cutworm infestations and aid in wireworm control.

2. **Use recommended rates of nitrogen**. Excessive rates of nitrogen fertilizer may delay maturity and make tobacco a more favorable host for hornworms and aphids after topping.

3. Adjust **transplanting date** to reduce tobacco susceptibility to insect pests. Early-planted tobacco is often less favorable for aphids and hornworms, and more favorable for budworms and flea beetles. Late-planted tobacco is highly susceptible to hornworm damage and may have lower yield and quality. Aphids are usually most serious on tobacco transplanted near the middle of the transplanting period.

4. **Destroy greenhouse transplants immediately after transplanting is completed to** keep aphids and other insects from developing high populations on the transplants and migrating to the field tobacco.

5. **Manage field borders to reduce insect habitat**. Keep field margins clear of weeds and tall grass to reduce feeding, breeding, and overwintering sites for grasshoppers and other insects that move from these sites into tobacco fields. After the tobacco is established and growing, leave uncut barriers between tobacco fields and hay fields that are heavily infested with grasshoppers.

6. **Top in the button or early flower stage** to eliminate food sources for budworms and to make the crop a less desirable host for aphids and hornworms.

7. Obtain e**ffective sucker control to** reduce food sources for hornworms, budworms, and aphids.

8. Destroy crop residues immediately after harvest is completed. **Stalk cutting and root destruction** reduce feeding and overwintering sites for hornworms, budworms, and flea beetles. This practice is most effective when done on a community-wide basis.

9. Plan **crop rotations to reduce infestations of soil-inhabiting insects.** Rotating tobacco with crops that are poor hosts of cutworms, white-fringed beetles, and wireworms.

10. Use conservation tillage to manage insect infestations. **Conservation tillage**, including no tillage and strip tillage, reduces aphid and flea beetle populations, but it may increase cutworm and slug infestations.

Natural control

Beneficial organisms, including predators, parasites, and pathogens, provide valuable control of several insect pests. For example, parasites often kill more than 80 percent of the budworms in tobacco fields, control similar to that obtained with foliar insecticides.

Hornworms are parasitized by *Cotesia congregata* whose larvae feed inside the caterpillars. When the larvae mature, they emerge through the backs of the hornworms and form egg-like cocoons. Tiny wasps emerge from these cocoons in a few days, mate, and seek out new hornworms to parasitize.

Stilt bugs are long-legged, slender, brown bugs that feed on hornworm and budworm eggs, aphids, and even small amounts of tobacco sap. Since stilt bugs feed on plant sap, systemic insecticides such as Temik may kill them.

Aphids are attacked by the adults and larvae of several species of lady beetles, lacewing and syrphid fly larvae. A red color midge larvae also feed on aphids after topping. A pathogenic fungus frequently controls aphids from July through September, especially in wet seasons. Although lady beetles, lacewings, and syrphid fly larvae are usually abundant on aphid-infested tobacco, they may not keep aphids below levels that will cause economic damage.

To preserve beneficial insects, scout fields and use economic thresholds to time insecticide applications and select insecticides with low impact on beneficials. These insecticides include *Bacillus thuringiensis (Bt)*, pymetrozine (Fulfill), emamectin benzoate (Denim), spinosad (Tracer), and methomyl (Lannate). Transplant water and tray drench applications of imidacloprid (Admire Pro) and thiamethoxam (Platinum) have limited direct impact on beneficials, but the systemic soil insecticide-nematicide Temik is harmful to stilt bugs.

Chemical control

Economic thresholds and field scouting are important tools in IPM. The economic threshold is that pest population or injury level that requires treatment with an insecticide to prevent economic damage to the crop. Fields are scouted or sampled at regular intervals (once a week) to determine when insect pests reach their thresholds. Foliar insecticides are then applied when scouting indicates that one or more pests have reached their economic thresholds. Insecticides applied as foliar, transplant-water, tray-drench, and soil treatments are extremely important tools in an IPM program. Many cultural and natural controls help reduce insect outbreaks, but it is almost impossible to grow a top-quality, high-yielding tobacco crop without using some insecticides.

Insect Control on Transplants Produced in the Greenhouse

Almost all of the tobacco transplants used in Virginia are produced in greenhouses. So far, insects have caused minor problems in greenhouses. However, if recommended cultural practices are not carried out, several insect species could become serious pests.

Ants can remove seeds from the trays and cause poor stands. **Cricket** feeding damage often destroys newly emerged tobacco seedlings, reducing stands and initial growth. **Shoreflies**, tiny flies that look like small houseflies, are frequently numerous in greenhouses. Their larvae (maggots) feed on young seedlings and may reduce stands during the first two weeks after germination. **Mice** also remove the seeds from float trays, seriously reducing plant stands. If stand loss is severe, the entire greenhouses must be reseeded due to this damage. In greenhouses with overhead watering systems, green **June beetle grub** may uproot seedlings in the trays.

Cutworms, crickets, vegetable weevils, and **slugs** usually feed on stems and leaves at night. Cutworms also cut off and destroy plants. **Crickets**, **cutworms**, slugs, and **yellow-striped armyworms** may destroy individual leaves on larger seedlings; this damage appears to do little harm. **Vegetable weevil** adults and larvae often feed on the leaves and stems and destroy the buds of seedlings.

Aphids often infest tobacco seedlings in the greenhouse building up high populations that reduce plant vigor, and they may be carried to the field on infested plants.

Cultural controls in the greenhouse

Sanitation is the most important practice for managing insect pests in tobacco greenhouses. The following practices reduce the potential for insect infestations in greenhouses.

- As soon as transplanting has been completed, discard all unused plants and clean out the greenhouse.
- Keep the area in and around the greenhouse clean and free of weeds, decaying plant material, plastic, rocks, wood, metal, and other habitats for insects and other pests to live and feed.

- Do not plant fall and winter gardens near the greenhouse. Aphids can survive on various vegetables and related weeds during the winter and develop winged aphids that can fly into the greenhouse and establish colonies on the tobacco seedlings.
- If greenhouses are used to produce other crops, there should be a fallow period to keep pests from moving from the other crops to the tobacco seedlings. Whiteflies or aphids could become problems if they move from these earlier crops to tobacco.
- Use extreme temperatures to kill insects hiding in the greenhouse. Close the greenhouse in the summer to increase the temperature and promote cold temperatures in the winter to reduce potential pest problems.
- Seed the entire greenhouse at the same time. Do not seed tobacco in greenhouses that are infested with large numbers of shore flies because the shore flies will lay eggs on the seedlings and the larvae will injure the emerging seedlings reducing stand and seedling uniformity
- Clean the greenhouse thoroughly just before seeding in the spring.

Chemical control in the greenhouse

Acephate (Orthene) is the only effective insecticide labeled for use on tobacco transplants grown in greenhouses (Table 1). It should be applied as a foliar spray when insect infestations are observed. It provides good to excellent control of aphids, yellow-striped armyworms, cutworms, flea beetles, and vegetable weevils. Do not apply acephate in the irrigation water or the float water. Acephate also gives effective control of ants when applied in the greenhouse before the float beds are set up. Apply the proper rate because too much acephate can injure or kill young plants.

Metaldehyde (Deadline Bullets) bait controls slugs and snails in the greenhouse. In the early evening, apply methaldehyde along walkways and the outside margins of the float beds. Do not apply methaldehyde directly to seedlings or use it in float beds. Mice should be controlled with baits labeled for their control.

Table 1. Insecticides for use on transplants grown in greenhouses

Insect	Insecticide and formulation	Rate per 1,000 sq ft
Aphids, cutworms, flea beetles	Acephate (Acephate AG) 75SP	1 tbs/3 gal of water (1 lb/A)
	(Acephate) 97UP	¾ tbs/3 gal of water (¾ lb/acre)
	(Orthene) 97PE	¾ tbs/3 gal of water (¾ lb/A)
Remarks and precautions: Apply as a spray. **Over application can cause plant injury. Do not apply through an irrigation system or in the float water.**		
Snails and slugs	Metaldehyde (Deadline Bullets) 4% bait	¼ to ½ lb
Remarks and precautions: **Slug damage is usually associated with shiny slime trails.** Apply to alleys, walkways, and vacant areas in late afternoon. **Do not apply to float water or directly on foliage**. It is deactivated by water.		
Ants	Acephate (Acephate AG) 75SP	1 oz/5 gal of water
	(Acephate) 97UP	
	(Orthene) 97PE	¾ oz/5 gal of water
Remarks and precautions: Apply 1 gal of mix to each mound area by sprinkling the mound until it is wet and treat a 4-ft diameter circle around the mound. Treat only once during the season.		

Insect Control on Newly Transplanted Tobacco

Wireworms

Wireworms are hard, yellowish-brown, wire-like larvae of click beetles that live in the soil, feeding on the roots and tunneling the piths of young tobacco plants. This injury stunts plant growth, causing irregular stands and lower yields. Although wireworms feed throughout the growing season, the most serious damage occurs during the first month after transplanting. Wireworms take one to five years to complete their life cycle. Most of this time is spent in the larval stage. The larvae emerge from eggs in the summer and fall, feed on the roots of various host plants, and overwinter into the next year. Larvae then feed on the newly transplanted tobacco. Pupation and emergence as adult click beetles occurs in late spring and early summer.

Wireworms are most common in fields with a history of wireworm problems, or in those previously planted after grass sod, weeds, corn, or small grains. In these situations, apply an insecticide labeled as soil, tray-drench or transplant-water treatments for wireworm control (Table 2). Apply soil insecticides (Lorsban or Mocap) as broadcast treatments and incorporate them at least two weeks before transplanting. Another option is to use Admire Pro or Platinum applied at the wireworm rates as transplant-water or transplant-drench treatments. The most effective cultural practice for wireworm control is to use sturdy, healthy transplants that are less susceptible to wireworm damage than tender, young transplants. After wireworm damage has occurred, it is too late to apply an insecticide. Where damage is light to moderate, cultivation and irrigation may help injured plants recover and produce near normal yields although crop maturity may be delayed. If wireworms seriously reduce the stand, replanting may be necessary. The field can be rebedded or turned under and replanted after a recommended soil insecticide is applied.

Cutworms

Cutworms are active at night, feeding on roots or leaves or cutting off entire plants. This injury can cause enough damage and stand loss to require replanting. However, since tobacco compensates well, less than five percent stand loss usually has no impact on yield. Cutworm infestations are very sporadic and difficult to predict, but they are most likely to occur in weedy fields that are plowed less than a month before transplanting. Plowing fields in the early spring usually reduces cutworm populations. Scout fields for cutworm damage once or twice a week during the first month after transplanting to determine when a remedial foliar treatment is needed (Table 8). For optimum control of this night-feeding pest, apply a foliar insecticide in late afternoon or early evening when 5 percent or more of the plants in a field have recent cutworm damage.

Whitefringed beetles

Whitefringed beetle grubs have become serious problems in some flue-cured and burley tobacco fields. Outbreaks usually occur in tobacco grown in rotation with clover, soybeans, or alfalfa. Most legumes are excellent food plants for the grubs, while most grasses are unfavorable hosts. Grubs feed on the outer surface of the taproots and tunnel into the pith of newly transplanted tobacco, killing or stunting the plants and causing serious yield reductions. Whitefringed beetles spread very slowly because all adult beetles are flightless female weevils. They are transported to new fields on farm equipment, water, and hay and other crops. No insecticides are currently registered for the control of whitefringed beetles on tobacco. The rotation of tobacco with good stands of grass containing few legumes or broadleaf weeds may help reduce grub damage.

Soil-incorporated insecticides

Pretransplant soil applications of insecticides can provide effective control of aphids, cutworms, flea beetles, wireworms, and nematodes on tobacco. However, foliar insecticides applied at the economic thresholds usually control insects feeding on the foliage and cost less than systemic insecticides applied to the soil.

Several factors should be considered before selecting a soil insecticide.

- Is there a field history of wireworms or nematode problems? If so, sample the field for nematodes as described in the disease control section of this guide and submit the samples to your local Extension office to be sent off for analysis. Fall sampling is best.
- If a tobacco field has been in sod, weeds, or small grains during the previous year or has a history of wireworm problems, apply an insecticide for wireworm control.
- Mocap, Capture, and Lorsban are broadcast soil treatments for wireworm control (Tables 2 and 3).
- Admire Pro or Platinum applied as transplant-water or transplant-drench treatments may be a better choice for wireworm control because they also control aphids and flea beetles (Tables 2, 4, and 5).

- Temik, the most effective contact nematicide, controls both insects and nematodes. However, when Temik is used, another insecticide may be needed to control wireworms (Tables 2 and 3).
- Soil fumigants provide little control of insects in the soil or on the foliage because many insects are below the zone being fumigated.

Table 2. Ratings of soil, greenhouse tray-drench, and transplant-water treatments for control of insects and nematodes on flue-cured tobacco.

	Leaf feeding insects		Soil insects		Nematodes[1]	
Insecticide	Aphids	Flea beetles	Cut-worms	Wire-worms	Root-knot and other	Tobacco Cyst
Acephate AG/TW[2]; Acephate UP; Orthene 97 (TW)[2]	2	3	3-4	0	0	0
Admire Pro,/Nuprid (TW)[2]	5	2	0	3	0	0
Admire Pro,/Nuprid (TD)[2]	5	4	0	3	0	0
Capture 2EC PPI, TPW	0	0	3	3	0	0
Lorsban 4E PPI	0	1	3	4	1 (5 qt/A)	0
Mocap 6EC PPI	0	1	2-3	3-4	1	0
Platinum/TMOXX 2F (TW)[2]	5	3	0	3	0	0
Platinum/TMOXX 2F (TD)[2]	5	4	0	3	0	0
Temik 15G PPI	4	2	0	0	3	3

Ratings are based on a scale of 0 to 5 where 0 = not labeled or no control, 1 = poor control, 2 = fair control, 3 = good control, 4 = very good control, and 5 = excellent control.
[1]Ratings for nematode control were made by Charles S. Johnson.
[2]TW = Transplant water, TD = Transplant drench, PPI=Preplant soil incorporated.

Table 3. Insects on field tobacco – pretransplant soil treatments

Insect	Insecticide and formulation	Rate per acre
Aphids (early season suppression of flea beetles)	Aldicarb (Temik) 15G **(Flue-cured only)**	10 to 14 lb
Remarks and precautions: Restricted Use. Apply granules in a 6- to 12-inch band and incorporate or cover with soil to a depth of 2 to 6 inches when forming beds. Transplant into treated area. Transplants are very sensitive to Temik applied in narrow bands. Therefore, narrow bands applied with a shank should be placed 4 to 6 inches from the root systems. Do not apply more than one week before transplanting. **Check the label for plant-back restrictions.**		
Wireworms, Cutworms	Ethoprop	1 $^{1}/_{3}$ to
	(Mocap) 6EC	4 qt
	(Mocap) 15G	13 lb
	Chlorpyrifos (Lorsban) 15G	13 ½ to 20 lb
	(Lorsban) 4E	2 to 3 qt
	Bifinthrin (Capture) 2EC	2.56 to 6.4 fl oz
Remarks and precautions: Make broadcast applications at least 2 weeks before transplanting. Band applications are usually less effective than broadcast treatments. Use a suitable device to incorporate insecticides into the soil to a depth of at least 4 inches immediately after application. Lorsban and Capture are also registered for cutworms and flea beetle larvae. **These chemicals are restricted use.**		

Table 4. Insects on field tobacco – transplant-water treatments

Insect	Insecticide and formulation	Rate per acre or 1,000 plants
Flea beetles, cutworms, thrips, suppression of aphids	Acephate	
	(Acephate AG) 75SP	1 lb/A
	(Acephate) 97UP	¾ lb/A
	(Orthene) 97PE	¾ lb/A
	Bifinthrin	
	(Capture)2EC	2.56 to 6.4 fl oz
Aphids, flea beetles	Imidacloprid	
	(Admire Pro) 4.6SC	0-5 to 0.6 fl oz/ 1,000 plants
	(Nuprid) 2F,	1.0 fl oz/ 1,000 plants
	Thiamethoxam	
	(Platinum/TMOXX) 2SC	0.5 to 0.8 fl oz/1,000 plants or 3 to 5 fl oz/A
Wireworms, thrips for suppression of tomato spotted wilt virus	Imidacloprid	
	(Admire Pro) 4.6SC	0.8 to 1.2 fl oz/ 1,000 plants
	(Nuprid) 2F,	1.4-2.8 fl oz/ 1,000 plants
	Thiamethoxam	
	(Platinum/TMOXX) 2SC	0.8 to 1.3 fl oz/1,000 plants or 5 to 8 fl oz/A

Remarks and precautions: Acephate provides flea beetle control for 3 to 4 weeks after transplanting and suppresses aphid infestations for 4 to 6 weeks. Admire Pro and Platinum usually give excellent season-long control of aphids. Apply treatments in at least 100 gal of water/A. Higher amounts of water should be used for greenhouse transplants. **Calibrate transplanters and allow tanks to run low before refilling.**

Table 5. Insects on field tobacco – drench application to greenhouse transplants

Insects	Insecticide and formulation	Rate per 1,000 plants
Aphids, flea beetles	Imidacloprid	
	(Admire Pro) 4.6SC	0.5 to 0.6 fl oz/ 1,000 plants
	(Nuprid) 2F	1.0 fl oz/ 1,000 plants
	Thiamethoxam	
	(Platinum) 2SC	0.5 to 0.8 fl oz
	(TMOXX) 2SC	
Wireworm, thrips for suppression of tomato spotted wilt virus	Imidacloprid	
	(Admire Pro) 4.6SC	0.6 to 1.2 fl oz/ 1,000 plants
	(Nuprid) 2F	1.4 to 2.8 fl oz/ 1,000 plants
	Thiamethoxam	
	(Platinum) 2SC	0.6 to 1.3 fl oz
	(TMOXX) 2SC	0.6 to 1.3 fl oz

Remarks and precautions: Apply as a drench to plants in trays or flats prior to transplanting. Mix with water before application. Keep agitated or mix regularly to avoid settling in tank. Water the plants in the trays before treatment and again immediately after application using enough water to wash the residue from the foliage into the media. Transplant within 3 days.

Remedial Control of Insects on Larger Tobacco

Scouting for Insects

Tobacco fields should be scouted at least once a week throughout the season to determine when insecticide applications are needed.

1. Take representative samples from the entire field except for the outside rows. Take samples in Z or N patterns across the field. Do not sample the same plants each week. Look for insect pests and their damage on at least 50 plants in a field (one to ten acres). Make counts and record the data for five consecutive plants at ten locations throughout the field. Select the plants before you see them. If a field is planted on two different dates or if there are great differences in plant size within the field, divide the field into two or more sections and sample each section separately. Large fields (more than ten acres) will require larger samples. Sample an additional ten plants for every two additional acres.
2. During the first four weeks after transplanting, check tobacco for feeding holes or missing, stunted, or cut plants. Cutworms, flea beetles, wireworms, and other insects may damage these plants.
3. Beginning about three to four weeks after transplanting, aphids, budworms, flea beetles, and hornworms are the primary targets of an insect scouting program.
4. When a field is being scouted for insects that feed on tobacco foliage, individual plants should be examined and recorded in a notebook as follows:
    a. Check the bud region for budworm damage. If damage is present, look carefully for budworms and the white cocoons of the budworms parasite, *Campoletis sonorensis*. If there is budworm damage, but no worm, do not count the plant as infested.
    b. Examine the entire plant for hornworm damage, locate, count the hornworms at least 1 inch long, and determine whether they are parasitized by *Cotesia congregate* (white egg-like cocoons on hornworm's back).
    c. Examine the undersides of upper leaves for aphids and the upper surfaces of the middle and lower leaves for honeydew, flea beetles, flea beetle feeding holes, and mines of the tobacco splitworm.
    d. If you find an unidentified insect that appears to be damaging the crop, collect the insect and samples of its damage, put them in a container, and take them to a local Extension agent for identification. This is important because beneficial insects are often mistaken for pests. In addition, the misidentification of a pest may lead to the selection of the wrong insecticide for its control.
5. Tobacco fields should be treated when one or more insect pests meet or exceed the threshold levels shown in Table 6.

Table 6. Economic thresholds for various insects on tobacco

Insect	Economic threshold	Time when insect is a problem (weeks after transplanting)
Aphids	50 or more aphids on any upper leaf on 5 of 50 plants.	4 weeks after transplanting to final harvest
Budworms	10 plants with one or more budworm per 50 plants until 1 week before topping.	3 weeks after transplanting to 1 week before topping
Cutworms	5 out of 100 plants with recent cutworm damage.	1 to 4 weeks after transplanting
Flea beetles	4 beetles per plant on tobacco less than 2 weeks old, 8 to 10 beetles per plant on 2- to 4-week-old plants, 60 beetles per plant on plants more than 4 weeks old.	Transplanting to 4 weeks after transplanting and from topping to final harvest
Grasshoppers	10 grasshoppers per 50 plants.	6 weeks after transplanting to final harvest
Hornworms	5 larvae (worms) at least 1 inch long per 50 plants. Do not count parasitized worms with the egg-like cocoons on their backs. For hornworms ½ to ¾ inch long, treat when there is 1 hornworm per plant.	3 weeks after transplanting to final harvest. Can be a problem on air-cured tobacco in curing structures
Wireworms	Not determined	1 to 6 weeks after transplanting

Tobacco budworms

Tobacco budworms feed in the buds of young tobacco plants causing many holes in the tiny developing leaves. As the leaves grow, these feeding holes become larger and give the plants a ragged, distorted appearance. Tobacco plants usually compensate for this damage so yield and quality may not be affected. However, budworms sometimes top the plants prematurely causing early sucker growth that may stunt the plants and require extra labor to remove the suckers. After the button stage, budworms rarely cause economic damage. Apply foliar sprays for budworm control with one or three solid-cone or hollow-cone nozzles over each row using 40 to 60 psi to deliver 10 to 25 gal/A of spray mixture. Control with foliar sprays rarely exceeds 80 percent. See insecticide performance ratings in Table 3 and insecticide options for budworm control in Table 8. When checking tobacco for budworms, look for the cocoons of a wasp (*Campoletis*) that parasitizes budworms on the leaves near the bud. These cocoons are about ¼ inch long and white or grayish in color with two black bands or dots. *Campoletis* and other parasites provide good natural control of budworms on tobacco in Virginia.

Hornworms

Tobacco and tomato hornworms are large caterpillars (up to 4 inches long) that eat large amounts of tobacco leaf. Infestations may develop anytime from transplanting until harvest, but damage is usually most severe during August and September. Treat for hornworm control where there are 5 hornworms 1 inch long or longer per 50 plants. Do not count parasitized hornworms. Parasitized hornworms with the white egg-like cocoons of the parasitic wasp, *Cotesia congregata*, on their backs eat much less than healthy hornworms and they provide a food source for parasites that help reduce the next generation of hornworms. Predators also kill large numbers of larvae that are less than 1 inch long. For this reason, hornworms less than 1 inch long are not considered when determining the economic threshold because they cause very little damage and have no effect on yield or quality. However, if a field has large numbers of hornworms less than 1 inch long, the field should be rechecked in 3 to 4 days. For optimum control of hornworms, direct the spray to the upper one-half of the plants. See insecticide ratings in Table 3 and the labeled insecticides in Table 9. Several cultural practices help reduce the susceptibility of tobacco to hornworms. Early topping, early transplanting, effective sucker control, and fertilization with recommended rates of nitrogen help reduce late-season infestations. When used on an area-wide basis, stalk cutting and root destruction immediately after harvest reduces overwintering hornworm populations.

Aphids

The tobacco or green peach aphid has been the most severe insect pest of tobacco in Virginia. Aphid populations increase rapidly, doubling in size in about every two days under favorable conditions. High populations of aphids can reduce tobacco yield by 5 percent to 25 percent (100 to 500 lbs/A) or more. As aphids feed, they excrete honeydew that contains the excess sugars obtained from the plant sap. This sticky, shiny honeydew and tiny white exoskeletons are deposited on the leaves below the feeding aphids. A dark, sooty mold that gives the leaves a dark tint often grows on the honeydew. The combination of sooty mold and honeydew interferes with curing, reduces leaf quality, and often remains on tobacco after aphids have been controlled. Aphids are most severe on field tobacco from late June to September. Tobacco plants become infested when winged aphids fly into fields and deposit young wingless nymphs on the upper leaves. Watch for increases in aphid populations from early June to the end of August. Examine the undersides of leaves from all portions of tobacco plants to assess the extent of aphid infestation.

The following practices can be used to manage aphids on tobacco.

1. **Preventive Control**

    a. **Apply systemic insecticides before or at transplanting.**

        1. Admire Pro or Platinum applied as transplant-drench or transplant-water treatments usually provide excellent season-long control of aphids (Table 2).

        2. Temik applied in a band before transplanting for nematode control also controls aphids (flue-cured tobacco only).

2. **Remedial Control of Aphids**

    a. **Make remedial applications of a foliar insecticide at the economic threshold level** before populations become too high (Table 3).

Aphids are then much easier to control for the rest of the season.

b. **Rotate insecticides for resistance management.** The continuous use of the same insecticide year after year increases the chances that aphids will develop resistance to it. Rotating insecticides with different modes of action reduces the chances that resistance will develop. The insecticides available for aphid control on tobacco are in several different groups based on their modes of action (the way they kill aphids). Orthene/Acephate is in group 1b, Lannate and Temik are in group 1a, Fulfill is in group 9a; and Admire, Platinum, Nuprid, Provado, Actara, are in group 4a. When applying several insecticides for aphid control over the growing season, change from one group to another. Do not apply a neonicotinoid such as Provodo, Actara, or Assail to tobacco already treated with another neonicotinoid such as Admire or Platinum. Instead, apply Orthene or Fulfill because they are in different chemical groups.

c. **Assess control after three or four days.** It takes one to three days after application of most insecticides for the aphids to die. If control is not adequate, determine whether the weather conditions, spraying equipment, improper calibration, or other factors contributed to the poor control.

d. **Higher gallonage, higher sprayer pressure, drop nozzles, and spreader-stickers can improve coverage.** For optimum aphid control with foliar insecticides, the sprays must come in contact with the aphids concentrated on the undersides of the leaves.

e. **Continue to scout the crop** after satisfactory control is obtained because aphid populations may return to damaging levels and require additional insecticide applications.

3. **Cultural Control of Aphids**

Most cultural practices do not keep aphid populations below the economic threshold, but they can improve the effectiveness of foliar insecticides and reduce the need for insecticide applications after topping. Useful cultural practices include:

a. **Not planting cole crops such as cabbage and turnips near greenhouses**. These plants are sources of aphids that can infest tobacco plants early in the growing season.

b. **Controlling aphids in greenhouses.** Destroy greenhouse transplants immediately after transplanting is completed.

c. **Transplanting early**. Early planted tobacco may become infested with aphids earlier, but it matures earlier and the aphids have less impact on it than they do on tobacco planted near the middle of the recommended planting period.

d. **Use recommended nitrogen rates on flue-cured tobacco.** Too much nitrogen fertilizer causes the leaves to remain green later in the year and it promotes excessive sucker growth that favors aphid infestations.

e. **Topping early and controlling suckers.** Aphid populations often decline rapidly after topping, especially in hot, dry weather. However, aphids may still reach damaging levels that require insecticide treatment.

Tobacco flea beetle

Adult tobacco flea beetles feed on the leaves and stalks of tobacco, while the grubs or larvae feed on tobacco roots. Extensive feeding by both beetle stages on newly set transplants may cause stunting and uneven stands. When checking tobacco fields for flea beetles, look for the characteristic shot-hole feeding damage, and then count the beetles on 20 plants (two per field-sample location). **Apply treatments for flea beetles on newly set tobacco when there are four or more beetles per plant**. Larger plants can tolerate very high flea beetle densities. Apply an insecticide when the base of the lower leaves have a netted appearance or densities exceed 60 beetles per plant. Flea beetle control ratings for systemic and foliar insecticides are listed in Tables 2 and 7, respectively. Insecticides for flea beetle control are listed in Tables 3, 4, 5, and 9). Harvesting at the normal time, and stalk cutting and root destruction immediately after the last harvest are the most effective cultural practices for reducing flea beetle damage. Tobacco with nitrogen deficiency appears to be more susceptible to flea beetle damage after topping.

Flea beetles are difficult to control after topping because the insecticides that can be used at this time provide only short residual control and flea beetles are emerging from the soil over an extended period.

Managing thrips to control tomato spotted wilt virus

The tobacco thrips, *Frankliniella fusca,* is the primary vector of the tobacco pathogen, tomato spotted wilt virus (TSWV). TSWV caused serious stand reductions in tobacco fields in parts of Virginia in 2002 but it has occurred at very low rates since then. Foliar treatments for thrips control are not effective for managing TSWV after the disease is observed in the field. However, tray-drench or transplant-water applications of Admire Pro and Platinum suppress TSWV. Tray drenches are more effective than transplant water treatments.

Tobacco splitworm

The tobacco splitworm or potato tuberworm is a leaf-mining caterpillar that is sometimes a late-season problem on tobacco. Splitworms live in tunnels or mines that appear as grayish, translucent blotches on the leaves. Splitworms can also feed in the midvein and stalk. Old mines turn brown and brittle and may destroy over 50 percent of the leaf. Although the mines are most common on the lower leaves, they can occur on any leaf. Splitworm damage increases the amount of dead leaf tissue and may reduce crop yield and value. Since splitworms feed within the leaves, they are difficult to control with insecticides. Currently, no insecticides are registered for splitworm control on tobacco. However, Denim, Tracer, and Acephate applied in high volumes of water provide fair to good control. Denim was the most effective treatment. Early-season applications of Warrior appear to be effective but are rarely necessary and no early-season thresholds have been established. Therefore, it is important to avoid planting or storing Irish potatoes near tobacco fields because they are important sources of this pest in tobacco. If splitworm mines are observed on the lower leaves, the leaves should be harvested and cured as soon as possible. Since splitworms continue to develop inside the leaves after they are harvested, removing infested leaves and dropping them on the ground will not reduce the problem and may make it worse.

Insecticide Application Methods

Apply insecticides properly for optimum insect control. On small tobacco, obtain effective control by directing one solid-cone or hollow-cone nozzle per row to the bud. Operate equipment at 40 to 60 psi, do not exceed 5 miles per hour, and use at least 6 to 8 gal/A of finished spray. After tobacco is 2 feet tall, use one or three cone nozzles per row. If three nozzles are used, orient the two side nozzles at a 45-degree angle toward the upper $^{1}/_{3}$ of the plant. Use 40 to 60 psi and 20 to 50 gal/A of spray mixture. Set the nozzles 8 to 12 inches above the tobacco. Drop nozzles oriented to the undersides of the leaves and used in combination with one or three nozzles over the row may improve aphid, splitworm, and flea beetle control. Plant tobacco uniformly so that the space between rows is constant. This makes it easier to orient the spray nozzles over the plants during the spraying operation.

Table 7. Rating of foliar insecticides for control of insect pests on flue-cured tobacco.

Insecticide	Aphid	BW[1]	CW[1]	FB[1]	G[1]	HW[1]
Actara/TMOXX	4	0	0	3	0	0
Assail	4	2	0	2	0	4*
Bacillus thuringiensis Spray Agree, Crymax/Dipel/Javelin/Lepinox/XenTari	0	2	0	0	0	5
Capture	1	3	4	3	3	5
Denim	0	4	0	0	0	4
Fulfill	3	0	0	0	0	0
Lannate	2	3	0	3	0	5
Orthene/Acephate/Acephate 97UP	4	3	4	3	4	5
Provado/Nuprid	4	0	0	3	0	0
Sevin	0	2	3	3	3	4
Thiodan/ Phaser	3	3	0	3	0	5
Tracer	0	4	0	0	0	4
Warrior	1	3	3	3	3	5

[1]BW = Budworm; CW = Cutworm; FB = Flea Beetle; G = Grasshopper; HW = Hornworm. Rating is as follows; 0 = not labeled, 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent, *effective, but not labeled.

Table 8. Restricted entry intervals and preharvest intervals for various insecticides used on flue-cured tobacco in Virginia.

Insecticide	Restricted entry intervals (REI) (hours)	Preharvest interval (PHI) (days)
Foliar treatments		
Acephate (Orthene/Acephate AG/Acephate UP)	24	3
Acetamiprid (Assail) 70WP, 30WG	12	7
Bacillus thuringiensis (Agree/Crymax/Dipel/Javelin/XenTari)	4	0
Bacillus thuringiensis (Lepinox)	12	0
Bifenthrin (Capture)	12	Do not apply after layby
Carbaryl (Sevin)	12	0
Endosulfan (Golden Leaf Tobacco Spray/Phaser/Thiodan)	24	5
Imidacloprid (Nuprid/Provado) 1.6F	12	14
Methomyl (Lannate)	48	7
Pymethozine (Fulfill)	12	14
Spinosad (Tracer)	4	3
Thiamethoxam (Actara/TMOXX))	12	14
Soil treatments		
Aldicarb (Temik) (Check label for reentry restrictions after first rainfall or irrigation)	48	Applied before transplanting
Bifenthrin (Capture)	12	Do not apply after layby
Chlorpyrifos (Lorsban)	24	"
Ethoprop (Mocap)	48	"
Metaldehyde (Deadline Bullets)	12	"
Greenhouse float tray or transplant water treatments		
Acephate (Orthene/Acephate)	24	Applied at or before transplanting
Bifenthrin (Capture)	12	Do not apply after layby
Imidacloprid (Admire Pro/Nuprid)	12	Applied at or before transplanting
Thiamethoxam (Platinum/TMOXX) 2F	12	"

Table 9. Insects on Field Tobacco Foliar Treatments

Insect	Insecticide and formulation	Rate per acre
Aphids	Acephate	
	(Acephate AG) 75SP	$^{2}/_{3}$ to 1 lb
	(Acephate) 97UP	½ to ¾ lb
	(Orthene) 97PE	½ to ¾ lb
	Remarks and precautions: Apply as a spray in 10 to 50 gal/A. Use highest rate for heavy infestations or if control was poor with previous application. If tobacco is large and aphids are established on the lower leaves, drop nozzles that orient spray to undersides of leaves improve control. Prime before treating.	
	Acetamiprid	
	(Assail) 70WP	0.6 to 1.7 oz
	(Assail) 30WG	
	Remarks and precautions: Apply as a spray in at least 20 gal/A. Do not apply to tobacco already treated with Admire Pro, Platinum, Provado, or Actara. Also provides fair control of hornworms.	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Imidacloprid	
	(Provado) 2F	2 to 4 fl oz
	(Nuprid) 2F	2 to 4 fl oz
	Remarks and precautions: Apply as spray. **Do not apply to tobacco treated with Admire Pro, Assail, Platinum, Provado, or TMOXX.**	
	Methomyl	
	(Lannate) 90SP	1 ½ pt
	(Lannate) 2.4LV	¼ to ½ lb
	Remarks and precautions: Apply as a spray. Several applications may be necessary to control aphids. **Restricted use.**	
	Pymetrozine	
	(Fulfill) 50WG	2 ¾ oz
	Remarks and precautions: Do not apply more than 5½ oz/A/year. Allow 7 days between applications.	
	Thiamethoxam	
	(Actara) 25WDG	2 to 3 oz
	Remarks and precautions: Do not apply to tobacco already treated with Platinum, TMOXX, Admire Pro, Assail, or Provado. Apply only once during the growing season.	
Armyworms (beet, fall and yellowstripped)	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Emamectin benzoate	
	(Denim) 0.16EC	6 to 12 fl oz
	Remarks and precautions: Restricted Use. Apply in sufficient water for through coverage.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply as a spray. Observe the 40-day preharvest interval. Orthene is labeled for armyworms on other crops.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Budworms	Acephate	
	(Acephate AG) 75SP	1 lb
	(Acephate) 97UP	¾ lb
	(Orthene) 97PE	¾ lb
	Remarks and precautions: Apply as a spray. When using hand sprayer apply in 10 to 50 gal/acre.	
	Bacillus thuringiensis Sprays	
	(Agree) WG	1 to 2 lb
	(Crymax) WG	½ to 2 lb
	(Dipel) DF	½ to 1 lb
	(Dipel) ES	1 to 2 pt
	(Javelin) WG	1 to 1 ¼ lb
	(Lepinox) WDG	1 to 2 lb
	(XenTari) WDG	½ to 2 lb
	Remarks and precautions: Apply as a spray. **Do not allow diluted sprays to stand in the sprayer more than 12 hours**.	
	Carbaryl	
	(Sevin) 80S	1 ¼ to 2 ½ lb
	(Sevin XLR Plus) 4F	1 to 2 qt
	Remarks and precautions: Apply as a spray. Do not apply until plants are established and growing. The tobacco aphid often becomes a problem on tobacco following two or more applications of Sevin.	
	Emamectin benzoate	
	(Denim) 0.16EC	8 to 12 fl oz
	Remarks and precautions: Restricted Use. Apply in sufficient water for through coverage. Apply before damaging infestations occur.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply as a foliar spray after field scouting indicates the population has reached the at the threshold as indicated by field scouting. Observe the 40-day preharvest interval.	
	Methomyl	
	(Lannate) 90SP	½ lb
	(Lannate) 2.4LV	
	Remarks and precautions: Apply as a spray. Make applications as needed. Direct the spray into the buds before buttoning. **Restricted Use.**	
	Spinosad	
	(Tracer) 4F	1½ to 2 fl oz
	Remarks and precautions: Use higher rates for large larvae or high infestation. Use at least 20 gal of water/A.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Cabbage loopers	Acephate	
	(Acephate AG) 75SP	1 lb
	(Acephate) 97UP	¾ lb
	(Orthene) 97PE	¾ lb
	Remarks and precautions: Apply as a spray in 10 to 50 gal of water.	
	Bacillus thuringiensis	
	See rates and formulations under budworms	
	Remarks and precautions: Apply as a spray. **Do not allow prepared sprays to stand in tank more than 12 hrs.**	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9 to3.8 fl oz
	Remarks and precautions: Restricted Use. Apply as a spray. There is a 40-day preharvest interval.	
	Methomyl	
	(Lannate) 90SP	½ lb
	(Lannate) 2.4 LV	1 ½ pt
	Remarks and precautions: Apply as a spray. **Restricted Use.**	
	Spinosad	
	(Tracer) 4F	1½ to 2 fl oz
	Remarks and precautions: Apply as a spray in at least 20 gal of water per acre.	
Cutworms	Acephate	
	(Acephate AG) 75SP	1 lb
	(Acephate) 97UP	¾ lb
	(Orthene) 97PE	¾ lb
	Remarks and precautions: Apply as a spray overtop of plants in affected areas when 5% of plants are injured by cutworms. Make application during late afternoon using at least 25 gal of spray/A.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply in the late afternoon when cutworms are causing damage. Do not apply within 40 days of harvest.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Flea beetles	Acephate	
	(Acephate AG) 75SP	2/3 lb
	(Acephate) 97UP	½ lb
	(Orthene) 97PE	½ lb
	Remarks and precautions: Apply as a spray. Prime before treating.	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Carbaryl	
	(Sevin) 80S	1 ¼ lb
	(Sevin XLR Plus) 4F	1 qt
	Remarks and precautions: Apply as a spray. Do not apply until plants are established and growing. Aphids often become problems on tobacco following two or more applications of Sevin.	
	Imidacloprid	
	(Provado) 1.6F	4 fl oz
	Remarks and precautions: Apply as spray. **Do not apply to tobacco already treated with Admire Pro, Assail, TMOXX, or Platinum.**	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply in sufficient water for coverage.	
	Methomyl	
	(Lannate) 90SP	¼ to ½ lb
	(Lannate) 2.4LV	1 ½ pt
	Remarks and precautions: Apply as a spray. **Restricted Use.**	
	Thiamethoxam	
	(Actara) 25WDG	2 to 4 oz
	Remarks and precautions: Do not apply to tobacco already treated with Admire Pro, Assail, Platinum, Provado, or TMOXX. Apply only once during the growing season.	
Grasshoppers	Acephate	
	(Acephate AG) 75SP	1/3 to 2/3 lb
	(Acephate) 97UP	¼ to ½ lb
	(Orthene) 97PE	¼ to ½ lb
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Carbaryl	
	(Sevin) 80S	2/3 to 1 7/8 lb
	(Sevin XLR Plus) 4F	½ to 1 ½ qt
	Remarks and precautions: Apply as a spray. Treat crop and a strip around field to reduce grasshopper movement into the field.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply in sufficient water for coverage. There is a 40-day preharvest interval.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Hornworms	Acephate	
	(Acephate AG) 75SP	$^2/_3$ lb in water (1 ½ tbs/gal of water)
	(Acephate) 97UP	½ lb
	(Orthene) 97PE	½ lb (1 tbs/gal)
	Remarks and precautions: Apply as a spray. Treat infested fields before worms are more than 1½ inches long. Direct insecticides toward the upper half of the plants. Prime before treatment.	
	Bacillus thuringiensis	
	(Agree) WSP	1 to 2 lb
	(Crymax) WG	½ to 2 lb
	(Dipel) DF	¼ to 1 lb
	(Dipel) ES	½ to 1 pt
	(Javelin) WG	$^1/_8$ to 1 ¼ lb
	(Lepinox) WDG	1 to 2 lb
	XenTari WDG	½ to 2 lb
	Remarks and precautions: Apply as a spray. Do not allow dilute sprays to stand in tank more than 12 hours. Dipel can be tank mixed with maleic hydrazide (MH-30).	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Carbaryl	
	(Sevin) 80S	1 ¼ to 2 ½ lb
	(Sevin XLR Plus) 4F	1 to 2 qt
	Remarks and precautions: Apply as a spray.	
	Emamectin benzoate	
	(Denim) 0.16EC	8 to 12 fl oz
	Remarks and precautions: Restricted Use. Apply in sufficient water for thorough coverage before damaging infestations occur.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply as a spray. There is a 40-day preharvest interval.	
	Methomyl	
	(Lannate) 90SP	¼ to ½ lb
	(Lannate) 2.4LV	¾ to 1 ½ pt
	Remarks and precautions: Apply as a spray. Restricted Use.	
	Spinosad	
	(Tracer) 4F	1 to 2 fl oz
	Remarks and precautions: Apply as a spray in at least 20 gal of water/A.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Japanese beetles	Acephate	
	(Acephate AG) 75SP	$^2/_3$ to 1 lb
	(Acephate) 97UP	½ to ¾ lb
	(Orthene) 97PE	½ to ¾ lb
	Remarks and precautions: Apply as a spray in 10 to 50 gal/A. Prime before treating.	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Carbaryl	
	(Sevin) 80S	1 ¼ lb or 3 tbs/gal of water.
	(Sevin) 50W	2 lb
	(Sevin XLR Plus) 4F	1 qt
	Imidacloprid	
	(Provado) 1.6F	4 fl oz
	Thiamethoxam	
	(Actara) 25WDG	3 oz
	Remarks and precautions: Apply as a spray. Damage is usually less severe than it appears. Repeated applications with sevin or pyrethroids may flare aphid flare-ups.	
	Lambda-cyhalothrin	
	(Warrior) 1EC	1.9-3.8 fl oz
	Remarks and precautions: Restricted Use. Apply as a spray. There is a 40-day preharvest interval.	
Slugs	Metaldehyde	
	(Dealine Bullets) 4 % Bait	12 to 40 lb/acre
	Remarks and precautions: Apply as a broadcast treatment to the soil surface in the late evening. Metaldehyde is most effective after irrigation or a rain.	
Stink bugs	Acephate	
	(Acephate AG) 75SP	$^2/_3$ to 1 lb
	(Acephate) 97UP	½ to ¾ lb
	(Orthene) 97PE	½ to ¾ lb
	Remarks and precautions: Apply as a spray. Stinkbug injury is usually much less severe than it appears.	
	Bifenthrin	
	(Capture) 2EC	2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Lambda-cyhalothrin	
	(Warrior) 1EC	
	Remarks and precautions: Restricted Use. Apply as a spray. There is a 40-day preharvest interval.	

Table 9. Insects on Field Tobacco Foliar Treatments (cont.)

Insect	Insecticide and formulation	Rate per acre
Thrips	Acephate (Acephate AG) 75SP (Acephate) 97UP (Orthene) 97PE	 1.9-3.8 fl oz
	Remarks and precautions: Apply as a spray in 10 to 50 gal/A. Use highest rate for heavy infestations or if control was poor with previous application. Prime before treating. Foliar applications for thrips control are not effective for reducing tomato spotted wilt virus after the disease is observed.	
	Bifenthrin (Capture) 2EC	 2.56 to 6.4 fl oz
	Remarks and precautions: Do not apply after layby. **Restricted use.**	
	Lambda-cyhalothrin (Warrior) 1EC	 $^{2}/_{3}$ to 1 lb ½ to ¾ lb ½ to ¾ lb
	Remarks and precautions: Apply as a spray. Foliar applications for thrips control are not effective for reducing tomato spotted wilt virus after the disease is observed.. There is a 40-day preharvest interval.	
Whitefringed beetle	No chemical controls **Remarks and precautions: Cultural control**: Rotate tobacco with grass crops. Control legumes and broadleaf weeds. **Do not plant tobacco after legumes.** No insecticides are currently registered for whitefringed beetle control on tobacco.	

CURING TOBACCO

T. David Reed, Extension Agronomist, Tobacco

Flue-cured Tobacco Curing

Curing flue-cured tobacco should be considered a complex procedure because of the differences in types of tobacco (body, stalk position, moisture content, etc.), curing facilities, and weather conditions. It is difficult to use a set curing schedule because each barn of tobacco is different.

The harvested leaves must be kept alive during the yellowing period so that desirable chemical and color changes can occur. At the same time, sufficient drying must take place so that when yellowing is completed the leaves will be thoroughly wilted. After the leaves reach the desired yellow color, the temperature should be raised to kill the tissue and stop further chemical and color changes. If the leaves are killed too early by drying too fast or high temperatures, the color will remain green. After the desired color (lemon-orange) is achieved, the remainder of the cure is merely a matter of drying the leaf and stems to preserve the color.

Tobacco producers may follow different temperature and humidity schedules and still obtain a satisfactory cure. The exact temperature schedule is not critical as long as it is within reasonable limits. S.N. Hawks, retired Extension tobacco specialist at North Carolina State University (NCSU), developed a Simplified Curing Schedule designed to reduce the complex curing procedure to its simplest terms. The three dry-bulb temperatures (100°F for yellowing, 130°F for leaf drying, and 160°F for stem drying) are well within safe ranges for each curing phase. Wet-bulb temperature for yellowing should be adjusted to fit the needs of the tobacco. The upper limits for leaf drying (105°F) and stem drying (110°F) are conservative.

The following points need to be remembered in following the Simplified Curing Schedule:

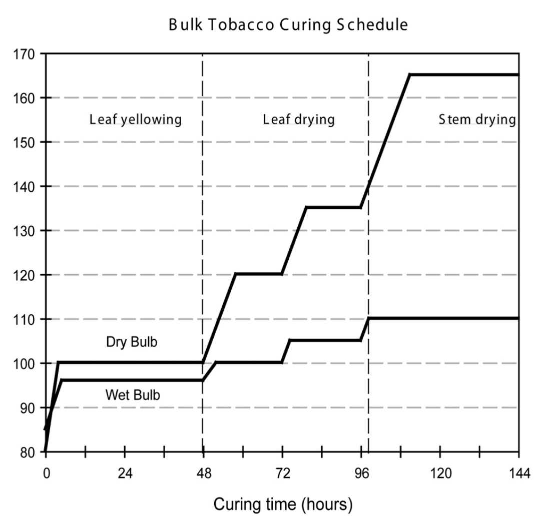
1. Remove all surface moisture from the leaves before beginning to yellow them. This may take up to 12 hours, depending on weather and tobacco conditions when the barn is filled. Lower leaves are often more difficult to yellow without developing soft rot.

2. Yellowing – Start heat at outside temperature and advance temperature 2°F per hour to 100°F. It may be necessary to open vents slightly during yellowing, but take care to avoid setting green color by lowering the relative humidity too much or drying too fast.

3. Maintain a dry-bulb temperature of 100°F until all leaves are yellow. Provide enough ventilation so that when the leaves become yellow, those on the bottom tier will be completely wilted. Generally, **a difference of 2° to 3°F between the wet- and dry-bulb reading should be maintained**.

4. Leaf drying – When leaves are yellow and sufficiently wilted, the dry-bulb temperature should be advanced 2°F per hour to 130°F. Increase ventilation enough so that the wet bulb does not exceed 105°F. Toward the end of the leaf-drying period it will usually be possible to reduce the amount of ventilation without exceeding 105°F on the wet bulb. A 130°F dry-bulb temperature should be maintained until all of the leaves on the lower two tiers are dry.

5. Stem drying – Dry-bulb temperature advanced 2°F per hour to 160°F and maintained until stems are dry. As long as the wet-bulb temperature does not exceed 110°F, ventilation can be reduced. Toward the end of the cure, the ventilators can be essentially closed to conserve fuel while drying stems.



A graphic representation of a bulk tobacco curing schedule provided by ______ Boyette and ______ Watkins of NCSU follows. This differs only slightly from what is described above, except that there is a momentary holding of the dry-bulb temperature at 120°F during leaf drying. This would provide for adequate removal of water from the tissue to avoid scalding or sweating the tobacco.

Retrofitting curing barns to indirect-fired heating focuses attention on heating efficiency and fuel consumption and this has only intensified with rising fuel prices. One measure of curing efficiency is the calculation of pounds of cured tobacco per gallon of fuel. Although there will be varieties dependent on the senor, the barn, and the tobacco. A reasonable value would be 10 pounds of tobacco per gallon LPG or 13 pounds per gallon of fuel oil. Higher weights of cured tobacco per gallon of fuel would indicate greater curing efficiency.

Simply increasing the amount of tobacco loaded into the barn may not necessarily result in increased curing efficiency. Uniformity in filling the barn has a substantial impact on air movement throughout the barn. To obtain optimum curing efficiency, barn filling rates must be compatible with the airflow capacity on the barn. With development of box loader systems and load cells to weigh tobacco, growers have been able to realize improved curing efficiency resulting from more uniformly filled barns.

Tobacco traditionally has been cured solely with the use of a dry-bulb temperature or the thermostat setting controlling the burner. A relatively few growers have made use of a wet-bulb thermometer to cure by. This is possible due to the wealth of knowledge that growers have developed for curing tobacco, experience with barns that have been used for many years, and a feel for the ripeness characteristics of their tobacco. However, the use of a wet-bulb thermometer is likely to be the single most important practice that can be used to reduce fuel consumption when curing tobacco. With older barns, some amount of added insulation and repair will reduce heat loss and most new barns have improved insulation. The use of a wet-bulb thermometer will help reduce the amount of over ventilation of the barn. Over ventilation, or opening dampers wider than necessary, increases the drying rate of the tobacco and the burner fires more to heat the inflow of outside air. Various wet-bulb thermometers or hygrometers (wet-bulb and dry-bulb thermometers) are available and many designs or homemade units are also available.

The dry-bulb temperature is a measure of the air temperature within the barn and is controlled by the thermostat on the burner. In contrast, the wet-bulb thermometer measures the temperature of the leaf tissue and is controlled by the amount of ventilation or the size of the damper opening. The difference between the dry-bulb and wet-bulb temperatures determines the relative humidity within the barn and, therefore, the amount of drying that occurs. Maintaining a high wet-bulb temperature within each stage of curing will reduce ventilation and thus increase curing efficiency. (See the Bulk Tobacco Curing Schedule graph).

Energy-Efficient Curing Practices

More than 90 percent of the energy used for the production of tobacco is used in the curing process. The following energy-efficient curing practices should be followed to help reduce the cost of curing.

1. Use a wet-bulb thermometer. Ventilate only enough to hold the humidity down (wet-bulb temperature); the wider the vent opening, the more fuel that is consumed.

2. Harvest only ripe tobacco; shorter curing times mean less heat loss and more efficient curing.

3. Load racks and boxes uniformly; uniform loading with no “tight spots” assures even drying and less energy use. Uniform barn loading reduces the length of the total cure.

4. Tune up the fuel burner; periodic maintenance and adjustment is required for efficient operation.

5. Stop hot-air leaks; check door gaskets and structure for cracks.

6. Assure an air seal around each rack or box; small cracks between boxes or racks reduces ventilation efficiency to a large degree.

7. Add insulation; well-insulated walls, roof, and floor can save 10 percent to 20 percent of fuel consumed per cure. Insulate new barn pads with 1-inch thick insulation board.

Tobacco-Specific Nitrosamines

Tobacco-specific nitrosamines (TSNAs) are considered to be a group of the most potent carcinogens found in tobacco. These compounds form by two different pathways. In burley tobacco and fire-cured tobacco, TSNAs are produced by naturally occurring microorganisms present on the leaves during curing. They feed upon natural compounds found in the tobacco leaf and produce TSNAs. Although curing conditions may be manipulated to modify TSNA levels, the curing season has a substantial input on TSNA levels found in stalk-cut tobaccos. The higher temperatures and accelerated drying of the leaf greatly reduce the activity of the microorganisms responsible for TSNA formation. However, the pathway for TSNA formation in flue-cured tobacco involves nitrous oxides (NOx) produced as a by-product of combustion of LP or fuel oil with alkaloids present in the tobacco. The use of indirect-fired heating, where a heat exchanger removes the combustion gases from the barn, has been found to reduce TSNA when compared to direct-fired curing barns.

In 1999, the Tobacco Industry Leadership Group proposed retrofitting all direct-fired bulk curing barns to indirect-fired heating. This became a requirement for the full-grade loan rate (price support) the following season and is currently required by contract purchasers. More than 30,000 barns were retrofitted across the flue-cured tobacco belts with some of the expense reimbursed by an industry supported cost-share program. Over the brief period of time since the barn retrofit program was implemented, the industry has recognized that the maintenance and testing of heat exchangers will be an ongoing process to ensure that leaks do not occur and NOx does not cause TSNA levels to increase. For the 2003 growing season, the Tobacco Industry Leadership Group has provided funding to tobacco extension programs in all tobacco producing states to conduct education programs to introduce the need for heat exchanger testing. In Virginia, local Extension agents have access to CO_2 meters for barn testing and will visit barns at a grower's request. This program is not intended to provide any form of barn certification and results of barn testing are reported only to the grower.

Barn Testing. Although NOx is the actual concern with a leaking heat exchanger, carbon dioxide (CO_2) will also be present in the curing air space. Carbon dioxide is measured because it is present in much higher amounts than NOx and measuring devices for CO_2 are much cheaper and portable than those for NOx. The procedure involves measuring the ambient CO_2 level (typically 350 to 500 ppm) in the barn with the burner off and then recording the increase in CO_2 above ambient in the barn after the burner runs for a sufficient time. Dampers are to be closed and the barn cannot contain green tobacco.

Interpreting CO_2 Meter Test Results:

- No increase in CO_2 above the ambient indicates that the entire system is intact at the time of testing.
- An increase in CO_2 less than 100 ppm indicates the present of a minimal leak somewhere in the furnace system.
- An increase in CO_2 between 100 and 200 ppm warrants further inspection of the furnace since a crack may be forming in the heat exchanger or a gap may be present in the exhaust stack.
- A doubling of the ambient CO_2 level indicates that a crack in the heat exchanger is likely.

Removing and examining a heat exchanger for a crack can be difficult. High-temperature (2,500^{o}F) caulking is available for minor repairs. Fortunately, the source of many leaks has been the exhaust stack. Any gap between the flue pipe and the heat exchanger or opening in the stack pipe may potentially allow exhaust gases to enter the curing chamber of the barn.

Although the use of indirect-fired curing removes NOx from the curing chamber, it is critically important to remember that microbial production of TSNAs may occur in flue-cured tobacco. It is important to remove any oxidized or barn-rotted leaves from tobacco before baling and do not bale tobacco with excessive moisture or compression. Each of these factors will impact the TSNA level of tobacco.

CALIBRATION

T. David Reed, Extension Agronomist, Tobacco

Proper calibration of both pesticide application equipment and fertilizer applicators is necessary to ensure that the intended amount of product is actually applied. This is especially important with pesticide sprayers to avoid potential crop injury from over application, to apply sufficient product to affect the target organism, and to avoid the added expense of over application.

Sprayer Calibration

The most convenient sprayer calibration procedure is the "1/128th acre" method. The basic principle is to determine the calibration distance to cover 1/128th of an acre based on the spacing of the spray tips. 1/128th of an acre is chosen because there are 128 ounces in a gallon and this allows for an easy determination of the application rate in gallons per acre with a measured output in ounces.

1/128th of an Acre Calibration Procedure

1. Determine the calibration distance to travel according to nozzle spacing from the chart below.

2. Record the travel time over the calibration distance with equipment attached and operating in appropriate field conditions at the desired speed.

3. Collect spray material (water) from a nozzle for the amount of time from step 2. Operate sprayer with the same engine speed as used to determine travel time and the desired sprayer pressure.

   Ounces collected per nozzle = gallons per acre

Calibration distances for various nozzle spacings

Spacing	Distance	Spacing	Distance
10 in.	408 ft.	30 in.	136 ft.
12 in.	340 ft.	36 in.	113 ft.
16 in.	255 ft.	40 in.	102 ft.
18 in.	227 ft.	42 in.	97 ft.
20 in.	204 ft.	44 in.	93 ft.
22 in.	186 ft.	46 in.	89 ft.
24 in.	170 ft.	48 in.	85 ft.

Example – For a broadcast boom with a nozzle spacing of 22 in. the calibration distance is 186 feet. The travel time with the sprayer in the field is found to be 32 seconds. Twenty-five ounces of water is collected from one nozzle for 32 seconds at the desired pressure so the application rate is 25 gal/A.

Note 1: When more than one nozzle is used per row with over-the-top applications, such as for sucker-control and insecticide sprays, collect the output from each nozzles per row and combine for a total for the row (this is not a banded application). The nozzle spacing is considered to be the row spacing.

Note 2: For banded applications, use the width of the spray band as the nozzle spacing. For example, with a 20-inch band with 48-inch row spacing, the travel distance is 204 feet. The treated acreage will be 42 percent of the acreage actually traveled (20 inches divided by 48 inches times 100).

Note 3: Transplanters may be calibrated using the 1/128th acre method. Pull the transplanter through the field and record travel time for the calibration distance based on transplanter row spacing, operating at the desired speed. Collect setter water from each unit for the corresponding travel time to determine application rate (ounces collected = gal/A for setter water application rate).

Note 4. Although the output of individual spray nozzles is collected to determine application rate, the output of multiple nozzles should be collected and compared to each other to verify the uniformity of the spray application. Replace any spray tip that is more that 10 percent off the average of all the nozzles.

Greenhouse Sprayer Calibration Procedure

1. Determine the appropriate distance to travel for calibration according to nozzle spacing on boom.

Nozzle Spacing	Calibration Distance
12 in.	78 ft.
14 in.	67 ft.
16 in.	59 ft.
18 in.	52 ft.
20 in.	47 ft.
22 in.	43 ft.
24 in.	39 ft.

2. Determine calibration time to travel the distance in Step 1.

3. Collect output from one nozzle for the calibration time.

4. Divide the number of ounces colleted by 10 to obtain application rate in gal. per 1,000 sq. ft.

Since greenhouse spray booms are typically pushed by hand, it is important to choose a pace that is easy to maintain and duplicate.

Example – A 35-x-250-foot greenhouse (8,750 square feet) is sprayed with a traveling boom having a nozzle spacing of 20 inches. The calibration distance is 47 feet and the travel time is determined to be 3 minutes 45 seconds. Water is run through the boom at the desired pressure and 54 oz. is collected from one nozzle. The application rate is 54/10 or 5.4 gallons per 1,000 square feet.

Calibration of Fertilizer Application Equipment

Accurate application of the desired amount of fertilizer is essential to supplying the proper nutrition to a tobacco crop. Proper calibration of application equipment will better ensure that the proper amount of fertilizer is applied. The "1/100 acre" method is one the easiest calibration procedures and does not require calibration charts and calculations.

1. The first step is to determine the appropriate calibration distance based on your row spacing.

Row spacing	Calibration distance
48 in.	109 ft.
46 in.	114 ft.
44 in.	119 ft.
42 in.	124 ft.

2. Collect fertilizer from the applicator over the calibration distance and weigh the fertilizer.

3. Multiply the amount of fertilizer collected times 100 to obtain the fertilizer application rate (lbs/acre).

With two outlets per row, fertilizer should be combined to obtain the application rate for the row.

Fertilizer should be collected separately from each row to determine the actual rate of each row.

Example - With a row spacing of 46 inches the calibration distance in 114 feet. If 7.25 pounds of fertilizer is collected from both outlets of a row applicator then the application rate is 7.25 times 100 or 725 lbs/A.

Individual rows of 2- or 4-row applicators should be within a 10 percent range of the intended rate. In the above example with 725 lbs/A, an acceptable range would be 690 to 760 lbs/A. Differences between rows become more important with higher nitrogen fertilizers (8-8-24 vs 6-6-18) or when applying nitrogen sidedress fertilizers.

Plant Population Chart

(plants per acre)

Plant Spacing (in.)	Row Spacing (in.) 42	44	46	48
16	9334	8910	8523	8168
17	8785	8386	8021	7687
18	8297	7920	7576	7260
19	7860	7503	7177	6878
20	7467	7128	6818	6534
21	7112	6789	6493	6223
22	6789	6480	6198	5940
23	6493	6198	5929	5682
24	6223	5940	5682	5445
25	5974	5702	5454	5227
26	5744	5483	5245	5026
27	5531	5280	5050	4840
28	5334	5091	4870	4667
29	5150	4916	4702	4506
30	4978	4752	4545	4356

For example: With a row spacing of 48 in. and a spacing of 22 in. between the plants within the row – the plant population is 5,940 plants per acre.

EPA WORKER PROTECTION STANDARDS FOR COMMONLY USED PESTICIDES FOR FLUE-CURED TOBACCO 2007

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The US-EPA Worker Protection Standard is a regulation that requires actions to be taken to protect agricultural workers from the risk of pesticide-related illness or injury. To protect your workers, you must be aware of the Worker Protection Standard (WPS) and know how to comply with its requirements. To plan effectively, you must also understand how compliance might affect your farming operation.

The Standard requires that employers provide for their workers and pesticide applicators in three areas. 1) Training on pesticide safety. Information about the specific pesticides used on the farm must be provided. Much of this information must be posted in a central location, including specifics on recent pesticide applications (location of application, name of the pesticide, EPA registration number and active ingredient, time and date of application, restricted entry interval (REI), and the time when workers may reenter the field). 2) Protection against exposure must be ensured. Employers must provide personal protective equipment (PPE) and be sure it is properly used and cleaned. They must also be sure that workers are warned about treated areas (through oral warning, posting of field, or both) and that workers do not enter treated fields during REIs (with some very specific exceptions). This may require careful scheduling of pesticide application and field work so that they do not conflict. PPE requirements vary from pesticide to pesticide and may be different for applicator/handlers and mixer/loaders. PPE is also required for entry into fields during the REI. Labels should be checked carefully for specific requirements. REIs also vary by pesticide, as stated on labels. 3) Employers must provide ways for their workers to mitigate or minimize the impacts of pesticide exposure. This includes making available decontamination sites and emergency assistance in case of exposure.

The following table lists products, registration numbers, common names, REIs, and posting/notification requirements for commonly used pesticides and growth regulators labeled for tobacco. The label may include more detailed information regarding PPE requirements. The information in this table is presented in good faith as a **reference only**. This information does not take the place of the product label; changes to label information can occur without notice. ***Always read and follow label directions.*** The list does not contain all products labeled for use on tobacco, but should include the vast majority of products used on tobacco in Virginia.

DISCLAIMER: The following information and worker protection standards are presented in good faith for your reference. This information does not take the place of the product label; changes to product label information can occur without notice. *Always read and follow label directions.*

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2] Applicators and Other Handlers	Personal Protective Equipment (PPE)[2] To Enter Treated Area Within REI[3]	Worker Notification[4] Oral	Worker Notification[4] Posted
Acephate ® 75SP AG (acephate) EPA Reg. No. 51036-236 Micro Flo **Acephate 97UP** EPA Reg. No. 70506-8 United Phosphorus	Caution	24 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; chemical resistant headgear for overhead exposure	coveralls; waterproof gloves; shoes plus socks; chemical resistant headgear for overhead exposure	either	either
(Actara 25 WDG (thiamethoxam) EPA Reg. No. 100-938 Syngenta Crop Protection	Caution	12 hrs.	long-sleeve shirt, waterproof gloves, shoes plus socks	coveralls, waterproof gloves, shoes plus socks	either	either
Actigard ® 50WG (acibenzolar-S-methyl) EPA Reg. No. 100-922 Syngenta Crop Protection	Caution	12 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves made of any waterproof material; shoes plus socks	coveralls, chemical-resistant gloves made of any waterproof material; shoes plus socks	either	either
Admire® Pro 4.6SC (imidacloprid) EPA Reg. No. 264-827 Bayer CropScience	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Agree® *(Bacillus thuringiensis var. aizawai* strain) EPA Reg. No. 70051-47 Certis USA	Caution	4 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; protective eyewear; dust/ mist filtering respirator	coveralls; waterproof gloves; shoes plus socks; protective eyewear	either	either
Aliette WDG Fungicide *(aluminum tris o-ethylphsophonate)* EPA REg. No. 264-516 Bayer CropScience	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves, shoes plus socks; protective eyewear	coveralls, waterproof gloves, shoes plus socks; protective eyewear	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2] Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Worker Notification[4] Oral	Posted
Alias ® 2F *(imidacloprid)* EPA Reg. No. 264-758-66222 Makhteshim Agan of North America, Inc.	Caution	12 hrs.	long-sleeve shirt and long pants, waterproof gloves, shoes plus socks, and chemical resistant headgear for overhead exposure	coveralls, chemical resistant gloves and shoes plus socks	either	either
Assail ® 70WP *(acetamiprid)* EPA Reg. No. 8033-23-4581 Cerexagri, Inc. **Assail ® 30WG** EPA Reg. No. 8033-36-82695	Caution	12 hrs.	long-sleeve shirt and long pants, waterproof gloves, shoes plus socks, and chemical resistant headgear for overhead exposure	coveralls, chemical resistant gloves and shoes plus socks	either	either
Brom-O-Gas® (98% methyl bromide) EPA Reg. No. 5785-4, -42 Great Lakes Chemical	Danger	48 hrs. and gas concentra-tion less than 5 ppm	loose fitting or well ventilated long-sleeve shirt and long pants; shoes and socks; fullface shield or safety glasses witwh brow and temple shields (NO GOGGLES); fullface respirator required when air concentration exceeds 5ppm.	non-handlers prohibited	yes	yes
Capture 2EC *(bifenthrin)* EPA Reg. No. 279-3114 FMC Corporation **Capture LFR 1.5EC** EPA Reg. No. 279-3302	Warning	12 hrs.	long-sleeve shirt and long pants, chemical-resistance gloves, such as Barrier Laminate or Nitrile rubber or Vitron; shoes plus socks, and protective eyewear	coveralls, chemical-resistant gloves, such as Barrier Laminate or Nitrile rubber or Neoprene rubber or Vitron, and shoes plus socks	either	either
Chlor-O-Pic® (99% chloropicrin) EPA Reg. No. 5785-17 Great Lakes Chemical **Chloropicrin 100®** EPA Reg. No. 8536-02-8853 Hendrix and Dail, Inc.	Danger	48 hrs. and gas concen-tration less than 0.1 ppm	loose fitting or well ventilated long-sleeve shirt and long pants; shoes and socks; fullface shield or safety glasses with brow and temple shields. (NO GOGGLES), full-face respirator when air concentration exceeds 0.1 ppm.	non-handlers prohibited	yes	yes

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Command ® 3ME EPA Reg. No. 279-3158 FMC CORPORATION EPA Reg. No. 279-3158-5905 Helena Chemical Co. EPA Reg. No. 279-315-34704 UAP-Loveland Products, Inc. EPA Reg. No. 279-3158-55467 Tenkoz, Inc.	Caution	12 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves, such as Barrier Laminate, Butyl or Nitrile rubber, or Viton; shoes plus socks.	coveralls; chemical-resistant gloves, such as Barrier Laminate, Butyl or Nitrile rubber or Viton; and shoes plus socks.	either	either
Crymax® (*Bacillus thuringiensis)* EPA Reg. No. 70051-86 Certis USA	Caution	4 hrs.	long-sleeve shirt and long pants; shoes plus socks; and dust/mist filtering respirator	coveralls; waterproof gloves; shoes plus socks; and protective eyewear	either	either
Deadline Bullets 4G (metaldehyde) EPA No. 64864-00002-AA-00000 Pace International	Caution	12 hrs.	long-sleeve shirt and long pants; shoes plus socks	long-sleeve shirt; shoes plus socks	either	either
Denim 0.16EC (emamectin benzoate) EPA Reg. No. 100-903 Syngenta Crop Protection	Danger	48 hrs.	coveralls worn over long-sleeve shirt and long pants, chemical-resistant gloves, chemical-resistant footwear plus socks, protective eyewear, chemical-resistant apron when cleaning equipment, mixing or loading.	coveralls over long-sleeve shirt and long pants, chemical-resistant gloves, chemical-resistant footwear plus socks.	either	either
Devrinol 2-EC (napropamide) EPA Reg. No. 70506-64 United Phosphorus, Inc.	Danger	12 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves such as Barrier Laminate or Viton ≥ 14 mils; shoes plus socks; protective eyewear	coveralls; chemical-resistant gloves such as Barrier Laminate or Viton ≥ 14 mils; shoes plus socks; protective eyewear	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE) [2]: Applicators and Other Handlers	Personal Protective Equipment (PPE) [2]: To Enter Treated Area Within REI[3]	Worker Notification[4]: Oral	Worker Notification[4]: Posted
Devrinol® 50-DF (napropamide) EPA Reg. No. 70506-36 United Phosphorus, Inc.	Caution	12 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves, shoes plus socks	coveralls; chemical-resistant gloves; shoes plus socks	either	either
Dipel® DF (*Bacillus thuringiensis*) EPA Reg. No. 275-103 Valent **Dipel® ES** EPA Reg. No. 73049-17	Caution	4 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Dithane® DF Rainshield (mancozeb) EPA Reg. No. 62419-402 SLN No. VA940001 Dow AgroSciences LLC	Caution	24 hrs.	coveralls over long-sleeve shirt and long pants; chemical resistant gloves; shoes plus socks	coveralls over long-sleeve shirt and long pants; chemical resistant gloves; shoes plus socks	either	either
Fair 85® (C6 - C12 fatty alcohols) EPA Reg. No. 51873-7 Fair Products	Warning	24 hrs.	long-sleeve shirt and long pants; chemical resistant gloves such as Barrier Laminate or butyl rubber or nitrile rubber or neoprene or polyvinyl chloride or Viton; shoes plus socks; protective eyewear	coveralls; chemical resistant gloves such as Barrier Laminate or butyl rubber or nitrile rubber or neoprene or polyvinyl chloride or Viton; shoes plus socks; protective eyewear	either	either
Fair Plus® (maleic hydrazide) EPA Reg. No. 51873-2 Fair Products	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; protective eyewear	coveralls; waterproof gloves; shoes plus socks; protective eyewear	either	either
FluPro (flumetralin) EPA Reg. No. 73631-2-400 Uniroyal	Warning	24 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves made of any waterproof material such as nitrile, butyl, neoprene, or barrier laminate; chemical resistant footwear plus socks	long-sleeve shirt and long pants; chemical-resistant gloves made of any waterproof material such as nitrile, butyl, neoprene, or barrier laminate; chemical resistant footwear plus socks; protective eyewear	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Forum *(dimethomorph)* EPA REg. No. 241-427 BASF Corporation	Caution	12 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves; shoes plus socks	long-sleeve shirt and long pants; chemical-resistant gloves; shoes plus socks	either	either
FST-7® (C10 fatty alcohol and maleic hydrazide) EPA Reg. No. 51873-6 Fair Products	Danger	24 hrs.	long-sleeve shirt and long pants; chemical resistant gloves such as Barrier Laminate, butyl rubber, nitrile rubber, neoprene, polyvinyl chloride, or Viton; shoes plus socks; protective eyewear	coveralls; chemical resistant gloves such as Barrier Laminate or butyl rubber or nitrile rubber or neoprene or polyvinyl chloride or Viton; shoes plus socks; protective eyewear	either	either
Fulfill® 50WDG **(**pymetrozine) EPA Reg. No. 100-192 Syngenta Crop Protection	Caution	12 hrs.	coveralls; chemical-resistant waterproof gloves, shoes plus socks	coveralls; chemical-resistant gloves, waterproof shoes plus socks	either	either
Lannate® L (methomyl) EPA Reg. No. 352-370 **Lannate® LV** EPA Reg. No. 352-384 DuPont	Danger	48 hrs.	long-sleeve shirts and long pants; chemical-resistant gloves; shoes plus socks; protective eyewear; exposure outdoors mist/dust filtering respirator	coveralls; chemical-resistant gloves; shoes plus socks, protective eyewear	either	either
Lannate® SP (methomyl) EPA Reg. No. 352-342 DuPont	Danger	48 hrs.	long-sleeve shirts and long pants; waterproof gloves; shoes plus socks; protective eyewear; exposure outdoors mist/dust filtering respirator (MSHA/NIOSH approval no. prefix TC-21C)	coveralls; waterproof gloves; shoes plus socks, protective eyewear	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]: Applicators and Other Handlers	Personal Protective Equipment (PPE)[2]: To Enter Treated Area Within REI[3]	Worker Notification[4]: Oral	Worker Notification[4]: Posted
Leven-38® (C10 fatty alcohol and maleic hydrazide) EPA Reg. No. 19713-105 Drexel	Danger	24 hrs.	coveralls over short-sleeved shirt and short pants; waterproof gloves; chemical- resistant footwear plus socks; protective eyewear; chemical-resistant headgear for overhead exposure; chemical-resistant apron when cleaning equipment, mixing or loading	coveralls over short-sleeved shirt and short pants; chemical-resistant footwear plus socks; protective eyewear, chemical-resistant headgear for overhead exposure	either	either
Lorsban® 4E (chlorpyrifos) EPA Reg. No. 62719-220	Warning	24 hrs.	long-sleeve shirt and long pants; chemical resistant gloves; shoes plus socks	coveralls; chemical-resistant gloves; shoes plus socks	yes	yes
Nemacur® 3 (fenamiphos) EPA Reg. No. 264-731 Bayer CropScience	Danger	48 hrs.	**see label for extensively detailed instructions for PPE**	coveralls over long-sleeve shirt and long pants; chemical resistant gloves, chemical-resistant footwear plus socks; chemical-resistant headgear (if overhead exposure)	yes	yes
Nuprid 2F (imidacloprid) EPA Reg. No. 228-484 Nufarm Americas, Inc **Nuprid 1.6F** EPA REeg. No. 228-488	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Off-Shoot T® (C6 - C12 fatty alcohols) EPA Reg. No. 57582-3 Cochran	Warning	24 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; protective eyewear	coveralls; waterproof gloves; shoes plus socks; protective eyewear	either	either
Orthene® 75S (acephate) EPA Reg. No. 59639-26 **Orthene ® 97** EPA Reg. No. 59639-91 Valent	Caution	24 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; chemical resistant headgear for overhead exposure	coveralls; waterproof gloves; shoes plus socks; chemical resistant headgear for overhead exposure	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Pasada ® 1.6 F (imidacloprid) EPA Reg. No. 264-763-6622 Makhteshim Agan of North America, Inc	Caution	12 hrs.	long-sleeve shirt and long pants, waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Pic Plus (chloropicrin) EPA Reg. No. 8853-6 Hendrix and Dail, Inc.	Danger	48 hrs. and gas concentration less than 0.1 ppm	coveralls or loose-fitting or well ventilated long-sleeve shirt and long pants; shoes and socks; full-face shield or safety glasses with brow and temple shields (**Do Not** wear goggles); full-face respirator when air concentration exceeds 0.1 ppm	non-handlers prohibited	yes	yes
Platinum ® 2SC (thiamethoxam) EPA Reg. No. 100-939 Syngenta Crop Protection	Caution	12 hrs.	long-sleeve shirt, waterproof gloves, shoes plus socks	coveralls, shirt, waterproof, gloves, shoes plus socks	yes	yes
Poast® (sethoxydim) EPA Reg. No. 7969-58-51036 SLN No. VA-980004 Micro Flo Co., LLC	Warning	12 hrs.	coveralls over short-sleeved shirt and short pants; chemical resistant gloves ≥14 mils; chemical resistant footwear plus socks; protective eyewear; chemical resistant headgear for overhead exposure; chemical-resistant apron when cleaning equipment, mixing and loading	coveralls over short-sleeved shirt and short pants; chemical resistant gloves ≥14 mils; chemical resistant footwear plus socks; protective eyewear; chemical resistant headgear for overhead exposure	either	either
Prep® (ethephon) EPA Reg. No. 264-418 Bayer CropScience	Danger	48 hrs.	coveralls over short-sleeved shirt and short pants; waterproof gloves; protective eyewear; chemical resistant footwear plus socks; chemical resistant headgear for overhead exposures; chemical resistant apron when cleaning equipment	coveralls over short-sleeved shirt and short pants; waterproof gloves; protective eyewear; chemical resistant footwear plus socks; chemical resistant headgear for overhead exposures	yes	yes

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Prime+® (flumetralin) EPA Reg. No. 100-640 Syngenta Crop Protection	Danger	24 hrs.	coveralls over short-sleeved shirt and short pants; chemical-resistant gloves such as Barrier Laminate or Viton; chemical-resistant foot-wear plus socks; protective eyewear; chemical resistant headgear for overhead exposure; chemical-resistant apron when cleaning equip-ment, mixing or loading	coveralls over short-sleeved shirt; short pants; chemical-resistant gloves such as Barrier Laminate or Viton; chemical-resistant footwear plus socks; protective eyewear; chemical-resistant headgear for overhead exposure	either	either
Provado 1.6F (imidacloprid) EPA Reg. No. 3125-457 Bayer Crop Protection	Caution	12 hrs.	long-sleeve shirt and long pants, waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Prowl® 3.3 (pendimethalin) EPA Reg. No. 241-337 BASF Corp. **Prowl® $H_2$0** (pendimethalin) EPA Reg. No. 241-418 BASF Corp. **Pendimax 3.3** EPA Reg. No. 68156-6-62719 Dow AgroSciences LLC	Caution	24 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves such as Barrier Laminate or Viton >14 mils; shoes plus socks	coveralls; chemical-resistant gloves such as Barrier Laminate or Viton >14 mils; shoes plus socks	either	either
Quadris (azoxystrobin) EPA Reg. No. 100-1098 Syngenta Crop Protection	Caution	4 hrs.	long-sleeve shirt and long pants; chemical-resistant gloves; shoes plus socks	coveralls; chemical-resistant gloves; shoes plus socks	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE) [2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Ridomil Gold EC ® (mefenoxam) EPA Reg. No. 100-801 Syngenta Crop Protection **Ridomil Gold SL ®** (mefenoxam) EPA Reg. No. 100-1202	Caution	48 hrs.	long-sleeve shirt and long pants, chemical-resistant gloves, shoes plus socks	coveralls, chemical-resistant gloves, shoes plus socks	either	either
Royal MH-30® (maleic hydrazide) EPA Reg. No. 400-84 Uniroyal Chemical	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	coveralls; waterproof gloves; shoes plus socks	either	either
Sevin® 4F (carbaryl) EPA Reg. No. 264-349 **Sevin® XLR Plus** EPA Reg. No. 264-333 Bayer CropScience	Caution	12 hrs.	long-sleeve shirt and long pants; chemical resistant gloves such as Barrier Laminate, butyl rubber, nitrile rubber, neoprene rubber, polyvinyl chloride (PVC), or Viton; shoes plus socks and chemical-resistant headgear for overhead exposure	coveralls; chemical resistant gloves such as Barrier Laminate, butyl rubber, nitrile rubber, neoprene rubber, polyvinyl chloride (PVC), or Viton; shoes plus socks and chemical-resistant headgear for overhead exposure	either	either
Sevin® 80S (carbaryl) EPA Reg. No. 264-316 Bayer CropScience	Warning	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks and chemical-resistant headgear for overhead exposure	coveralls; waterproof gloves; shoes plus socks and chemical-resistant headgear for overhead exposure	either	either
Spartan 4F (sulfentrazone) EPA Reg. No. 279-3220 FMC Corporation	Caution	12 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	coveralls over long-sleeve shirt and long pants; waterproof gloves; shoes plus socks	either	either

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Sucker Plucker® (C6 - C12 fatty alcohols) EPA Reg. No. 19713-35 Drexel	Warning	24 hrs.	coveralls over short-sleeved shirt and short pants; waterproof gloves; protective eyewear; chemical resistant footwear plus socks; chemical resistant headgear for overhead exposure; chemical resistant apron when cleaning equipment, mixing or loading	coveralls over short-sleeved shirt and short pants; waterproof gloves; protective eyewear; chemical resistant footwear plus socks; chemical resistant headgear for overhead exposure	either	either
Sucker Stuff® (maleic hydrazide) EPA Reg. No. 19713- **Super Sucker Stuff®** EPA Reg. No. 19713-20 Drexel	Caution	12 hrs.	long-sleeve shirt and long pants; shoes plus socks; waterproof gloves	coveralls; waterproof gloves; shoes plus socks	either	either
Telone® C-17 (1,3-Dichloropropene and Chloropicrin) EPA Reg.No. 62719-12 Dow AgroSciences LLC	Danger	5 days	**see label for extensively detailed instructions for PPE**	Non-handlers prohibited; **see label for extensive instructions for handlers**	yes	yes
Telone® II (1,3-Dichloropropene) EPA Reg. No. 62719-32 Dow AgroSciences LLC	Warning	5 days	**see label for extensively detailed instructions for PPE**	Non-handlers prohibited; **see label for extensive instructions for handlers**	yes	yes
Temik 15G (aldicarb) EPA Reg. No. 264-330 SLN No. VA820013 Bayer CropScience	Danger	48 hrs. Do not contact damp soil after the first rain or irrigation	coveralls over short-sleeved shirt and short pants, waterproof gloves, protective eyewear, chemical resistant footwear plus socks, chemical resistant headgear for overhead exposure, chemical resistant apron when cleaning equipment, mixing or loading	coveralls over short-sleeved shirt and short pants, waterproof gloves, chemical resistant footwear plus socks, protective eyewear and chemical-resistant headgear for overhead exposure	yes	yes

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Terramaster 4EC (etridiazole) EPA Reg. No. 400-422 Chemtura USA Corporation	Danger	12 hrs.	long-sleeve shirt and long-pants, chemical resistant gloves such as barrier laminate or viton, shoes plus socks, NIOSH approved respirator, chemical-resistant apron when mixing, etc.	coveralls, chemical-resistant gloves such as barrier laminate or viton, shoes plus socks, protective eyewear	yes	yes
TMOXX ® 2SC (thiamethoxam) EPA REg. No. 100-939-51873 Fair Products	Caution	12 hrs.	long-sleeve shirt, waterproof gloves, shoes plus socks	coveralls, shirt, waterproof, gloves, shoes plus socks	yes	yes
Tracer® 4 (spinosad) EPA Reg. No. 62719-267 SLN No. VA980001 Dow AgroSciences	Caution	4 hrs.	long-sleeve shirt and long pants; shoes plus socks; waterproof gloves	coveralls; waterproof gloves; shoes plus socks	either	either
Ultra Flourish (mefenoxam) EPA Reg. No. 55146-73 NuFarm Americas, Inc.	Warning	48 hrs.	long-sleeve shirt and long pants, chemical-resistant gloves, shoes plus socks, protective eyewear	coveralls, chemical-resistant gloves, shoe plus socks, protective eyewear	yes	yes
Vapam HL® (metam sodium) EPA Reg. No. 5481-468 AMVAC **Metam CLR®** EPA Reg. No. 45728-16 Taminco, Inc. **Sectagon 42®** EPA Reg. No. 61842-6 Tessenderlo Kerley, Inc.	Danger	48 hrs.	coveralls over long-sleeve shirt and long pants; waterproof gloves; chemical-resistant footwear plus socks; chemical-resistant headgear for overhead exposure; chemical-resistant apron when cleaning equipment, or when mixing, loading, or transferring without dry-disconnect fittings; face-sealing goggles, unless full-face respirator is worn; respirator with proper prefilter/canister	**Non-handlers prohibited.** Handlers performing allowed tasks must wear coveralls over long-sleeve shirt and long pants; waterproof gloves; chemical-resistant footwear plus socks. **Plus handlers must also wear if pungent, rotten egg odor of this product can be detected** face-sealing goggles, unless full-face respirator is worn; and a respirator	yes	yes

Product Trade Name (common name) EPA Reg. No. Company Name	Signal Word	Restricted Entry Interval (REI)[1]	Personal Protective Equipment (PPE)[2]		Worker Notification[4]	
			Applicators and Other Handlers	To Enter Treated Area Within REI[3]	Oral	Posted
Warrior (lambda-cyhalothrin) EPA Reg. No. 100-1112 Syngenta	Warning	24 hrs	long-sleeve shirt and long pants, chemical resistant gloves, shoes plus socks, protective eyewear	coveralls, chemical resistant gloves, shoes, plus socks	either	either
XenTari® WDG (*Bacillus thuringiensis)* EPA Reg. No. 275-85 Valent	Caution	4 hrs.	long-sleeve shirt and long pants; waterproof gloves; shoes plus socks; dust/mist filtering respirator (MSHA/NIOSH approved number prefix TC-21C)	coveralls; waterproof gloves; shoes plus socks	either	either

[1]Exception: If the product is soil-injected or soil-incorporated, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if there will be no contact with anything that has been treated.

[2]Represents the minimum PPE required; more protective clothing can be worn. See product label for recommended chemical-resistant glove materials.

[3]Refer to "Early Entry Work Situations" in *The Worker Protection Standard for Agricultural Pesticides—How to Comply,* pages 59-61, "Short-Term Tasks," "Emergency Tasks," and "Specific Tasks Approved by EPA Through a Formal Exception Process." See pages 45-47 for information on "Restrictions During and After Applications" including exceptions: 1) "Early Entry With No Contact" and 2) "Early Entry With Contact for Short-Term, Emergency," or "Specially Excepted Tasks."

[4]**Notification on Farms, Forests, and Nurseries:** Refer to page 41, *The Worker Protection Standard for Agricultural Pesticides—How to Comply.* Unless the pesticide labeling requires both types of notification, notify workers either orally or by posting of warning signs at entrances to treated areas. You must inform workers which method of notification is being used.

Both Oral Warning and Posted Signs: Some pesticide labels require you to notify workers both orally and with signs posted at entrances to the treated area. If both types of notification are required, the following statement will be in the "Directions for Use" section of the pesticide labeling under the heading Agricultural Use Requirements: "Notify workers of the application by warning them orally and by posting warning signs at entrances to treated areas."

COMMONWEALTH of VIRGINIA
VIRGINIA BRIGHT FLUE-CURED TOBACCO BOARD
P. O. Box 129
Halifax, Virginia 24558

ANNUAL REPORT

JULY 1, 2006 - JUNE 30, 2007

MISSION: To plan and conduct campaigns of sales promotion, advertising, publicity, research and education for the purpose of increasing the demand for and consumption of Virginia flue-cured tobacco.

COMPOSITION OF BOARD: The Board is composed of seven tobacco producers appointed by the Governor, who is guided in his appointments by recommendations of organizations representing flue-cured tobacco producers. The members represent legislatively-defined flue-cured tobacco producing areas in Virginia.

FUNDING: Funds to support the programs of the Board come from an excise tax paid by all flue-cured tobacco producers. The excise tax levy is 20 cents per hundred pounds of tobacco sold. The excise tax levied is collected by flue-cured tobacco marketing centers and company receiving stations at the time the tobacco is sold by producers and is subsequently remitted to the Board. The Board is responsible for ensuring that the tax has been properly collected and remitted.

BOARD PROGRAMS:

I. Market Development and Promotion:

The Board, by contractual agreement, provided $48,000 to Tobacco Associates, Inc. to be used in various market development and promotion projects. Tobacco Associates, Inc. is the U. S. tobacco producers promotional organization whose main objective is to promote U. S. flue-cured tobacco throughout the world. Tobacco Associates is funded through producer assessments in all flue-cured tobacco producing states -- in Virginia's case by virtue of the appropriation by the Board. Tobacco Associates is governed by a producer-controlled board of directors of which two members are from Virginia.

On behalf of U. S. growers, Tobacco Associates conducted U. S. leaf utilization programs and leaf grading seminars in selected countries, hosted foreign customers and prospective clients, participated in trade fairs and exhibits worldwide and informed producers and farm organizations concerning pertinent international tobacco market developments.

II. Research

The Board funded four research projects on flue-cured tobacco, which were conducted at the Virginia Tech Southern Piedmont Agricultural Research and Extension Center. Funds available from the Board enabled researchers and extension specialists to conduct timely production research in entomology, pathology, and agronomy.

III. Education

The Board provided funding for the printing of the annual Flue-cured Tobacco Production Guide, which was prepared and distributed to producers by the Virginia Cooperative Extension Service. This publication provided current information to producers on all aspects of flue-cured tobacco production.

FINANCIAL STATEMENT

July 1, 2006 - June 30, 2007

Revenue:		
Cash Balance - July 1, 2006	$ 32,597.43	
Excise Tax Receipts	84,207.95	
Total		$ 116,805.38
Expenditures:		
Administration	$ 956.34	
Market Development and Promotion	48,000.00	
Research	29,467.15	
Education	2,357.34	
Total		$ 80,780.83
Cash Balance - June 30, 2007		$ 36,024.55

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This information is being provided in accordance with legislation passed in the 1990 Virginia General Assembly requiring that each commodity board provide an annual report to its excise-tax paying producers.

Notes

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